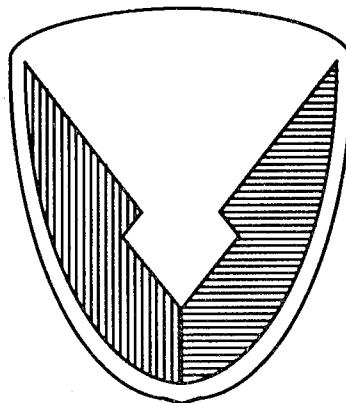


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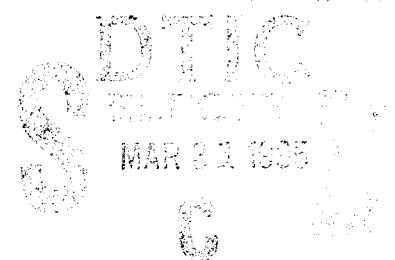
MICOM PAMPHLET

MICOM-Pam. 702-1 (H)

**QUALITY ENGINEERING HANDBOOK
FOR THE
PREPARATION AND MAINTENANCE
OF
QUALITY ASSURANCE
REQUIREMENTS AND PROVISIONS**



19950329 036



US ARMY MISSILE COMMAND

HEADQUARTERS US ARMY MISSILE COMMAND

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CHAPTER 1
GENERAL1-1 PURPOSE

This pamphlet provides a guide for Government and contractor personnel responsible for the preparation and implementation of the quality engineering (QE) requirements prescribed in contract statements of work (SOWs). It also provides instructions for the preparation, implementation, and maintenance of quality assurance provisions (QAPs) for weapon systems, end items, and materiel controlled, used, or procured by the United States Army Missile Command (MICOM). This pamphlet is to be used by MICOM in conjunction with Army Materiel Command (AMC) Regulation 702-10. The proponent of this pamphlet is the Product Assurance Directorate (PAD), Research, Development, and Engineering Center, MICOM. Government personnel are invited to send comments to the Commander, MICOM, ATTN: AMSMI-RD-QA-QE, Redstone Arsenal, AL, 35898-5290. Contractor comments or questions should be referred to the appropriate procurement contracting officer or as specified in the applicable contract.

1-2 SCOPE

This pamphlet covers both the preparation of QE requirements for inclusion in contract SOWs and the preparation of QAPs for inclusion on drawings, in specifications, depot maintenance work requirements (DMWRs), technical manuals, and storage serviceability standards (SSSs). It also provides an understanding of how QAPs fit into the overall quality concept and specifically provides for the following:

- a. The increased emphasis on front end loading of quality assurance (QA) programs, thus providing for the design of quality into a weapon system. The design and test activities are closely monitored to assure that all requirements are met, and that shortcomings, which might become production quality issues, are identified and resolved. This reduces the risk associated with the transition from development to production.
- b. The emphasis on total quality management (TQM).
- c. The detailed discussion of all quality requirements.
- d. The elimination of acceptable quality levels (AQLs).
- e. The emphasis on innovative QA techniques such as statistical process control (SPC), environmental stress screening (ESS), and electronic parts rescreening.
- f. The use of critical safety item (CSI) program requirements.
- g. The use of the Army Streamlined Acquisition Process.
- h. The integration of reliability requirements into QAPs.
- i. The acquisition, maintenance, and control of inspection equipment (IE).
- j. The guidelines for developing contractual SOWs.

1-3 THE QUALITY CONCEPT

1-3.1 The term "quality assurance" denotes the objective to assure a quality product, but the methods of accomplishing this objective vary. These methods have evolved and will continue to evolve with advancements in system technologies, computer science, and management techniques.

1-3.2 Government QA was originally directed towards inspection and was based on the logic that screening and sampling by the Government would assure quality. Due to the magnitude of this effort and duplication of work already performed by the contractor, most of these functions were turned over to the contractor with more emphasis given to Government surveillance. This concept was still based on the idea that inspection would assure quality. Although inspection and acceptance activities are necessary Government functions, experience has shown that these activities alone will not assure quality. Quality must be designed into a weapon system and

maintained throughout all the phases of the system's life cycle. Inspection is one means by which the Government obtains a certain degree of confidence that QA is being performed adequately. Other means are tightly controlled manufacturing processes, manufacturing process studies, adaptive process control indicators, SPC and audits. The QA activity uses these means along with others to provide greater confidence that the quality of design, conformance to the design, and field support activities are adequate to ensure fitness for use. This type of philosophy has led to the integration of QA into all phases of the system's life cycle.

1-3.3 The objective of this pamphlet is to provide guidelines that will lead to a more uniform application of the QA methods and techniques. Consistent applications of QA philosophies among all Army activities are important for Government/contractor interface.

1-3.4 This pamphlet also provides aid to the QA manager, the quality engineer (QE), and the QA specialist in understanding the QA concept and how to prepare, implement, and maintain QAPs.

1-4 TOTAL QUALITY MANAGEMENT (TQM)

1-4.1 The management philosophy focused on achieving quality, productivity, and efficiency through continuous process improvements is known as TQM. A posture statement from the Secretary of the Army and the Army Chief of Staff defines Army TQM as "an approach which continuously improves the processes by which our products are developed. It is a tool which must become an integral part of every functional activity in the Army; at all levels, in every organization, Government and industry".

1-4.2 The TQM implementation for acquisition is intended to reflect every aspect of this definition. It establishes short and long term strategies for orienting all levels of the work force to a process rather than a product. This concept demands top management's leadership and continuous involvement in the process activities. The successful TQM operation is characterized by an organization of trained and motivated employees, working in an environment where managers encourage creativity, initiative, and trust, and where each individual's contributions are actively sought to upgrade quality. Both productivity and quality teams play an important role in the TQM process.

1-5 QUALITY ASSURANCE (QA)

1-5.1 The QA activity provides a planned and systematic pattern of the actions necessary to develop technical requirements for a weapon system that are compatible with established Government requirements. The primary objective of QA is to assure that the materiel acquired by the Government satisfies contractual requirements.

1-5.2 The quality of a product depends on the integrity of the design, effectiveness of the QAPs, capability of the manufacturing processes, diligence of the support operations, and the competence and pride of workmanship of each individual. It is of critical importance that any QA program be based on a solid foundation of clear assignments of responsibilities by both the Government and the contractor. Any or all of the quality effort may be contracted, but the Government retains ultimate responsibility for QA management. It is imperative that quality managers, engineers, and specialists understand the QA concept and responsibilities so that the appropriate application of QAPs can be applied in order to achieve the desired quality levels. The use of QAPs has the potential of reducing the Government/contractor risks and acquisition cost/schedule constraints.

1-5.3 The objective of a QA program is to assure that the Government is provided with materiel that will perform the required mission, on schedule, and at a reasonable cost. There are

numerous functions and techniques available to accomplish this objective. The QE must be able to judiciously select, tailor, implement, and maintain the appropriate techniques and functions that will result in an effective quality program. These techniques and functions are addressed in this pamphlet.

1-5.3.1 There are five major phases of the acquisition process (Figure 1-1) and QA is active to different degrees in each one of them. During the Concept Exploration and Definition phase, the QA program and requirements are initiated, and QAPs are developed for the system specification. During the Demonstration and Validation phase, the QAPs for the development specifications are established and the special inspection equipment (SIE) is identified. During the Engineering and Manufacturing Development phase, the SIE design concept is defined, and the design, procurement, fabrication, and validations are accomplished. The development of QAPs for the technical data package (TDP) is also accomplished during this phase and the TDP validation begins. The QAPs for maintenance, storage, and field documents are developed just prior to the end of the Engineering and Manufacturing Development phase and are maintained or improved during the Production and Deployment and the Operations and Support phases.

1-5.3.2 During the development of the QA program, QA requirements, QAPs, and SIE, the quality manager is generally faced with the decision of when, where, and how to apply these functions and requirements with available resources. In designing quality into a system, the quality manager must first know what the requirements are and then must follow closely the development and test programs to ensure that the design is meeting these requirements, that the TDP reflects the design, and that the QAPs, ESS and SIE are adequate. By participating in the design stage, the quality manager is in a position to identify the areas that do not meet Government requirements and to either resolve them or minimize their potential impact on production.

1-5.3.3 Other techniques used to assure that quality and reliability are designed and built into the system include the following:

- a. The derating of system designs to assure that the parts perform satisfactorily when operated below their design stress levels.
- b. The use of high reliability parts.
- c. Preliminary procedures for ESS, rescreening, and fracture mechanics to assure that the design includes adequate fatigue, resistance, stress relief, and safety margins.
- d. Reliability growth management to assure that design maturity is achieved such that the product will meet its required level of performance.

1-5.3.4 In the final analysis, any design problem that is not resolved in development will become a problem in production. A problem is not considered resolved until corrective action has been implemented and a successful retest has been conducted. Only through close attention to the design and test processes can the quality manager assure a smooth transition (all quality issues addressed and controlled) from development into production.

1-5.3.5 The quality program should be a dynamic program, readily adaptable and responsive to state of the art advances in design, development, production, and field use of modern weapon systems. It should be a comprehensive program, made up of many elements necessary to assure quality. The program should fluctuate and expand as new, more effective techniques and functions are developed. This pamphlet provides for these elements and the guidelines for implementation thereof.

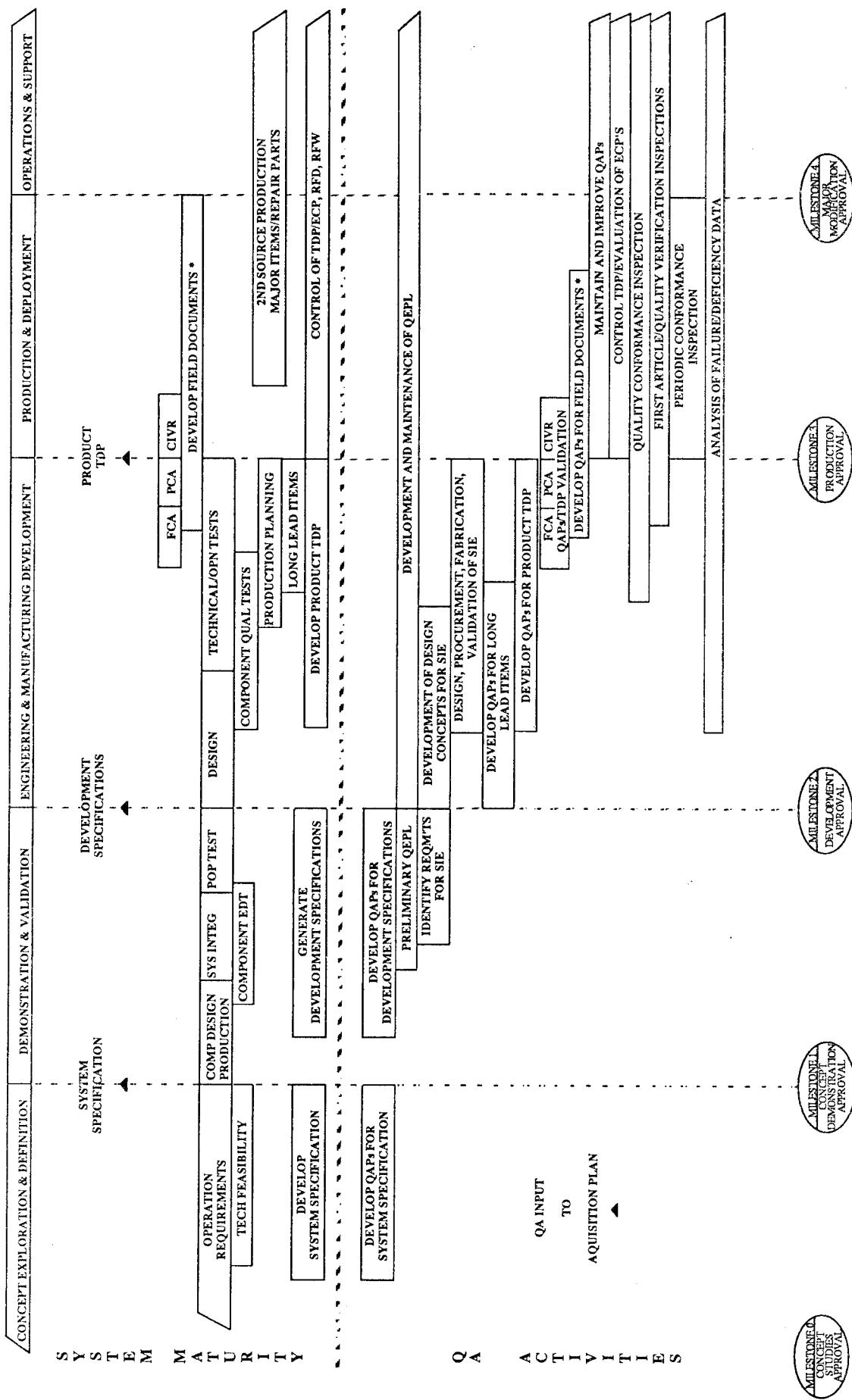


Figure 1-1. Quality Assurance Program Activities

* FIELD DOCUMENTS INCLUDE DMWRs, SSSs AND TMs.

CHAPTER 2

QUALITY ASSURANCE REQUIREMENTS

2-1 THE QUALITY PROGRAM

2-1.1 In today's world of advancing technology and high rate production, the quality program is expanding with more techniques and procedures. To accomplish better quality for the various products being produced, new programs are constantly being developed and implemented with greater attention being focused on proven procedures to produce quality products. With these proven procedures, quality is now reducing the risks associated with cost and schedule. The philosophy of solidifying cost effective QA is resulting in customer satisfaction, enhanced reputation, and greater profits. A modern comprehensive quality program consists of the following requirements in addition to the requirements of MIL-Q-9858:

- a. Statistical sampling,
- b. Statistical process control (SPC),
- c. Environmental stress screening (ESS),
- d. Critical safety item (CSI) program,
- e. Electrostatic discharge (ESD) sensitive device control,
- f. Software quality assurance (SQA),
- g. Inspection requirements,
- h. Inspection equipment (IE) development, validation, and control,
- i. Quality engineering planning list (QEPL),
- j. Training/certification,

2-1.2 This chapter defines the basic principles of the above requirements as related to the quality program. Chapter 3 provides guidelines for specifying the QAPs necessary to assure that the requirements are effectively developed, documented, implemented, and maintained throughout the life of the system.

2-1.3 Other requirements that help constitute an effective quality program are TQM, parts rescreening, and parts control. This pamphlet does not address TQM separately because TQM is a philosophy which should be fully integrated into the quality program requirements. Parts rescreening and parts control are not addressed because these functions are assigned to the Advanced Technology and Methodology Division of PAD.

2-2 MIL-Q-9858, "QUALITY PROGRAM REQUIREMENTS"

2-2.1 MIL-Q-9858 is the backbone of all Department of Defense (DOD) contractors' QA programs. Although primarily written for the control of products, the document can be tailored for other contractual programs. It provides broad based requirements for the development, documentation, and implementation of a contractor's basic QA program. It was written in broad terms so that it may be adapted to a wide variety of contractors' programs and provides the flexibility necessary to work in conjunction with various contractors' techniques and procedures. Furthermore, it is adaptable to all programs where complexity, criticality, and cost dictate an intensive, cost effective, and well documented QA program.

2-2.2 MIL-Q-9858 was first approved for use by DOD on 9 April 1959 and was followed by the "A" revision on 16 December 1963. Amendment 1, approved 7 August 1981, changed the referenced MIL-C-45662, "Calibration Systems Requirements" to MIL-STD-45662. Amendment 2, approved 8 March 1985, preserves Amendment 1 and also requires the contractor to furnish quality cost data to the Government upon request.

2-2.3 MIL-Q-9858 is invoked into contracts for items of such complexity that the requirements of MIL-I-45208 are insufficient to provide the quality control necessary to produce an acceptable product. It is invoked into contracts for complex or critical items by the Departments of the Army, Navy, and Air Force and the Defense Supply Agency. It requires the contractor to have an effective and economical quality program that is planned, documented, and developed in consonance with his other administrative and technical programs. It covers such areas as quality organization and planning, work instructions, records, corrective action, costs related to quality, technical documentation and changes, inspection and inspection equipment, tooling used for inspection, metrology requirements, control of purchases and suppliers, manufacturing control, handling, storage and delivery, nonconforming material, statistical quality control, the Government's right to inspect, and Government furnished property.

2-3 STATISTICAL SAMPLING

2-3.1 Introduction.

2-3.1.1 Items purchased in large quantities, such as nuts, bolts, ammunition, and electronic components, are often determined to be either conforming or nonconforming based on the inspection of a sample of the items. Such procedures are called "sampling inspection" or "statistical sampling".

2-3.1.2 Sampling inspection generally takes place at various stages of manufacturing such as inspection of incoming material, inspection at various stages of production, and inspection of the final product.

2-3.1.3 The purpose of sampling inspection is not an attempt to control quality but is to determine a course of action (accept/reject a product) so as to assure satisfactory quality. Controlling quality can be accomplished only by controlling the design of the product and the production processes. However, an indirect result of sampling inspection is that quality generally improves. A high rejection rate which results in lost profit and the threat of losing business gives the contractor an incentive to improve his quality.

2-3.2 The Need for Sampling Inspection.

2-3.2.1 The Government would like for all products acquired from contractors to conform to contractual requirements (zero defectives). The only way to approach zero defectives is by 100% inspection (screening) and/or tight manufacturing process controls. Screening is expensive, time consuming, and sometimes impractical due to the destructive nature of the inspections. Furthermore, screening does not always assure zero defectives because of mistakes made due to fatigue, boredom from repetitive inspections, and variation of the IE.

2-3.2.2 Screening may be required for certain critical items, but for many items, tight process controls with sampling inspection will provide adequate assurance for product conformance. However, with sampling inspection, there are certain risks involved which may allow the acceptance of a lot containing defective items. Tight manufacturing process controls and effective sampling plans that do not allow defects in the sample significantly reduce those risks. Therefore, when the decision is made to use sampling inspection, the risks involved need to be evaluated and an effective sampling plan selected which will provide the desired quality level.

2-3.3 The Department of Defense (DOD) Policy on Sampling Inspection.

2-3.3.1 For many years, sampling plans were based on a parameter known as the AQL. This was largely due to the influence and widespread use of MIL-STD-105 and its revisions. This subjective factor, along with its associated factor, "Lot Tolerance Percent Defective (LTPD)," was

used to design sampling plans that defined both "good" quality and "bad" quality. The undesirable feature of this approach was that the AQL concept would accept as good quality a process that produced, on average, less than 100% good product. Based on this philosophy, many of the sampling plans in the commonly used military standards on sampling allow acceptance of product even with one or more defects found in the sample. This philosophy is incompatible with today's philosophy of striving for zero defects. A further discussion of the factors, AQL and LTPD, is presented in Appendix C.

2-3.3.2 DOD will no longer accept the philosophy that good quality may be less than 100% conforming product. The only acceptable percent defective that is considered for a process average is zero. Under this philosophy, the AQL and LTPD are no longer chosen levels of acceptable nor unacceptable quality (percent defective) and therefore become meaningless. Screening is probably the only way to verify 100% conforming product but, in many cases, is impractical due to economics, time constraints, or the destructive nature of the inspection.

2-3.3.3 Recognizing that screening is often impractical, DOD accepts sampling as a valid process which must be conducted when conditions warrant, but, even then, only where an effective sampling plan with an acceptance number of zero can be devised. If no defects are found in the sample, there is a high probability that there are no defects in the lot. This will result in more reliable weapons for the soldier. An example of the probability of acceptance of a lot for two acceptance numbers with a given fraction defective (c) is illustrated in Figure 2-3.1. The zero acceptance number, therefore, forces the contractor to improve quality, which can likely be accomplished with the proper use of SPC. This provides for greater consumer protection.

2-3.3.4 DOD's position is that minor characteristics, as defined in MIL-STD-109, should be controlled by the contractor's quality program and not by Government imposed inspection criteria. However, it should be remembered that the Government retains the right to inspect procured material at any time and, if necessary, to exercise disapproval procedures in accordance with (IAW) the applicable contract. This position makes it necessary to classify only critical and major characteristics with the appropriate inspection criteria since all other characteristics are assumed to be minor and their inspection criteria normally left to the contractor. This position places a great deal of emphasis on proper classification of the characteristics. The classification must be concurred in by the contractor's QE element and the Government.

2-3.4 Lotting, Types of Inspection, and Methods of Sampling.

2-3.4.1 Lotting. Before a plan can be selected for sampling inspection, the size and nature of the lot must be known. For sampling inspection to be statistically valid (effective), the lot must consist of a specified quantity of homogeneous items (items produced from the same batches of raw materials and from components and parts manufactured on the same fabrication and assembly lines at the same facility with the same molds, dies, and patterns in a defined unit of time). A lot must be submitted for inspection in such a manner that every item is available for a random sample selection.

2-3.4.2 Two types of inspection for a unit of product are as follows:

- a. Attributes Inspection. The item or characteristics of the item are classified as nondefective or defective with respect to the given requirements.
- b. Variables Inspection. A specified quality characteristic of an item measured on a continuous scale such as length, weight, speed, hardness, and voltage.

2-3.4.2.1 The features of each of these types of inspection are summarized in Table 2-3.1.

VALUES FOR OC CURVES (N = 10)

No of Def. in the Lot D	Frac. Def. of the Lot $p' = \frac{D}{N}$	Probability of Acceptance (Pa)	
		Plan 1 (n = 3, c = 0)	Plan 2 (n = 3, c = 1)
0	0	1.000	1.000
1	0.1	.700	1.000
2	0.2	.467	.934
3	0.3	.292	.817
4	0.4	.167	.667
5	0.5	.083	.500
6	0.6	.033	.333
7	0.7	.008	.183
8	0.8	0	.066
9	0.9	0	0
10	1.0	0	0

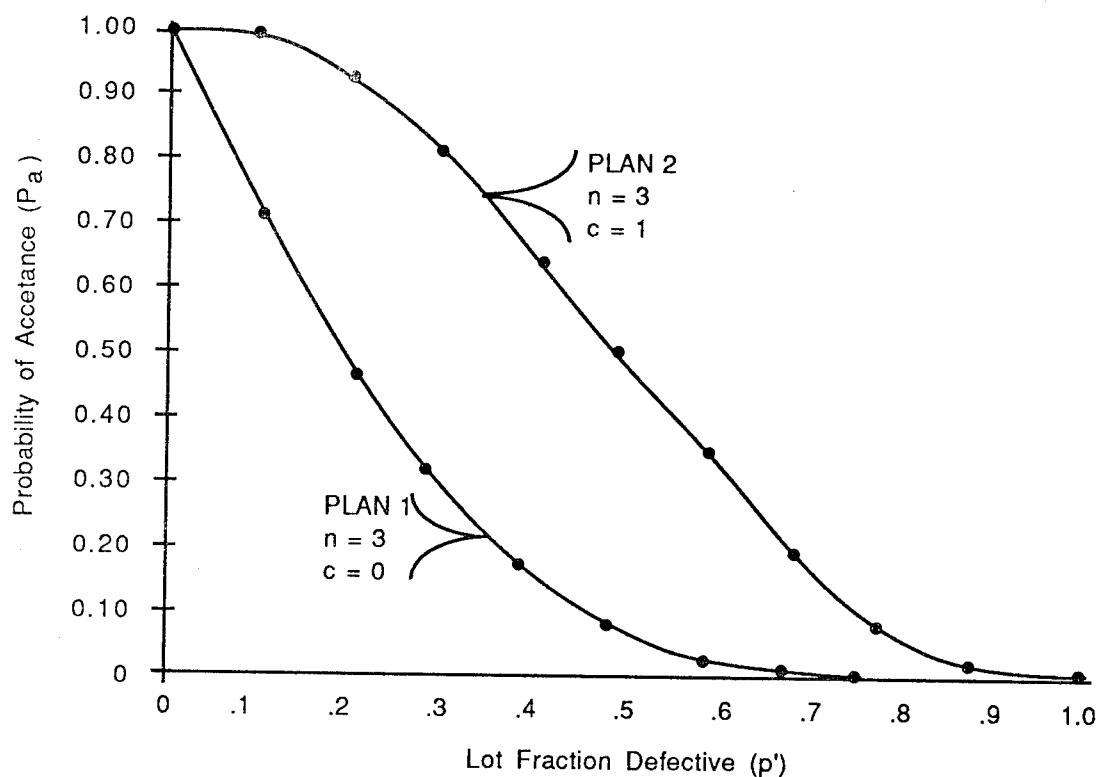


Figure 2-3.1 Operating Characteristics (OC) Curves for Two Sampling Plans

	ATTRIBUTES	VARIABLES
Type of inspection required.	Each item classified defective or non-defective. Few computations required.	Measurement must be taken on each item. Higher inspection skill required.
Sample size.	Larger number of samples required.	Saving of at least 30% in sample size (for single sampling on only one characteristic).
Assumption of underlying distribution.	None.	Some distribution must be assumed (usually normal).
Number of characteristics reviewed in one sample.	As many as desired under the same class of defectives or defects.	For each characteristic to be reviewed, a separate sampling plan is required.
Type of information provided by sample.	Number of defectives.	Valuable estimates of the process average and variation.

Table 2-3.1 Attributes vs. Variables Inspection

2-3.4.3 Two general methods of sampling product are as follows:

- a. Lot by Lot Sampling. When a group (lot) of homogeneous items produced over a specified time frame are sampled for inspection.
- b. Continuous Sampling. When an item is periodically selected at random from a moving line of product for the purpose of inspection.

2-3.4.3.1 MIL-STD-105 provides guidelines for lot by lot attributes inspection, whereas MIL-STD-414 provides guidelines for lot by lot variables inspection. These documents are AQL oriented and contain sampling plans that allow for the acceptance of a lot where the sample contains one or more defects. These plans are no longer acceptable for final product acceptance. All sampling plans to be used now for final product acceptance will specify the zero acceptance number ($c = 0$).

2-3.4.3.2 MIL-STD-1235 provides guidelines for continuous sampling by attributes and indexes its sampling plans by AQL. There are other publications that the contractor might use that contain "accept on zero" sampling plans for various lot sizes or lot sizes that can be mathematically derived, but these plans must be approved by the Government. Examples of "accept on zero" plans are shown in Figure 2-3.2.

2-3.5 Fundamentals of Lot Sampling Inspection by Attributes.

2-3.5.1 This lot sampling inspection procedure is used when the product to be inspected can be grouped into stationary predetermined lot sizes (N). The sampling plan will consist of the following:

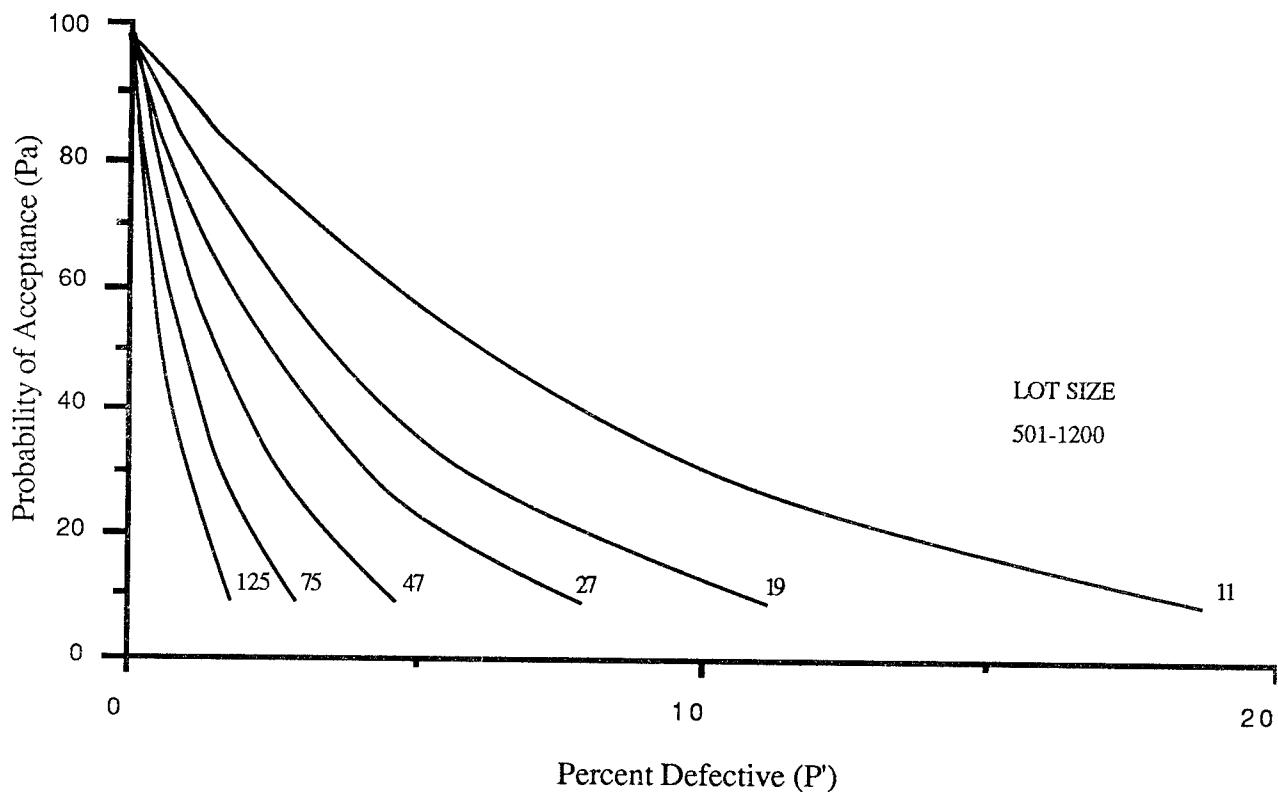


Figure 2-3.2 OC Curves for Single Sampling Plans, Acceptance Number Equal to Zero

- a. Sample Size (n). The number of units sampled from the lot.
- b. Acceptance Number (c). The maximum number of defectives allowed in order to accept the lot. As indicated above, this number is zero for all sampling plans used for acceptance of Government materiel.

2-3.5.2 In lot sampling inspection by attributes, n items are randomly selected from the lot and are inspected and classified as either nondefective or defective in consonance with the quality requirements. If c defective items are found, the entire lot is accepted. If more than c defective items are found, the entire lot is rejected. Sampling plans where $c = 0$ are known as "accept on zero" sampling plans

2-3.6 Operating Characteristic (OC) Curves

2-3.6.1 The effectiveness of a sampling plan is shown by its OC curve. The abscissa (horizontal axis) of this curve is the fraction or percent defective (p') of the lot being sampled. The ordinate (vertical axis) is the probability that such a lot will be accepted (Pa) when utilizing the sampling plan. Figure 2-3.1 illustrates a $c = 0$ plan (plan 1) and a $c = 1$ plan (plan 2) for the same lot using the same sample size.

2-3.6.2 As previously stated, there is the possibility of accepting poor quality lots when sampling is performed. The probability of this happening can be evaluated by the OC curve.

2-3.6.3 In order to show how an OC curve can measure the effectiveness of a sampling plan, consider a lot size (N) of 10 items with two different sampling plans.

- a. For sampling plan 1, let $n = 3$ and $c = 0$.
- b. For sampling plan 2, let $n = 3$ and $c = 1$.

2-3.6.3.1 The first step in constructing an OC curve is to prepare a table, computing the Pa for each plan relative to various values of the p' . This information is contained in the table of Figure 2-3.1 (the computation of Pa values is beyond the scope of this pamphlet). Using the values from the table of Figure 2-3.1, the OC curves for the two plans can be constructed as shown in Figure 2-3.1.

2-3.6.3.2 By comparing the OC curves in Figure 2-3.1, it can be seen that plan 2 allows for a greater probability of accepting a lot than does plan 1, except at each end of the range. Thus, plan 2 imposes a greater risk for the Government because of the greater probability that a poor quality lot would be accepted. For example, if $D = 2$ and $N = 10$, then 2 of the 10 items in the lot are defective and $p' = 0.20$. The probability that the lot would be accepted under plan 1 is 0.467, as compared to 0.934 for plan 2.

2-3.7 Classification of Characteristics, Defects, and Defectives

2-3.7.1 A characteristic is defined as any specified technical (design) requirement of an item such as material, finish, hardness, dimension, function, and workmanship. An example of a dimension characteristic is, "Characteristic, 0.050" \pm 0.001" Dim". This example specifies what is to be inspected and the acceptance criteria.

2-3.7.2 A defect is defined as a characteristic that does not conform to its specified requirements. A defective is defined as a unit of product which contains one or more defects.

2-3.7.3 The characteristics/defects of a given unit of product are generally grouped into one of three classes according to the degree of seriousness (MIL-STD-109) and are as follows:

a. A critical characteristic/defect is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product or is likely to prevent the performance of the tactical function of a major end item.

b. A major characteristic/defect is one, other than critical, that is likely to either result in failure or reduce materially the usability of the unit of product for its intended purpose.

c. A minor characteristic/defect is one that is not likely to reduce materially the usability of the unit of product for its intended purpose or one that is a departure from specified requirements but has little bearing on the effective use or operation of the unit.

2-3.7.4 It is the responsibility of the QE element to properly classify characteristics/defects IAW the above definitions. This requires intimate knowledge of the design and intended function of the characteristic and is usually accomplished with support from the design element.

2-3.7.5 Critical characteristics are always required to undergo 100% inspection (screening) except where such inspections are destructive or prohibitively expensive. In such cases, tightly monitored SPCs must be instituted and documented.

2-3.7.6 Certain major characteristics such as the function of tightly toleranced or difficult to control interfaces require the same inspection level as critical characteristics. Other major characteristics such as loosely toleranced interfaces may be sampled to relatively tight criteria using $c = 0$ sampling plan. All interfaces are considered by MICOM to be either critical or major characteristics.

2-3.7.7 Minor characteristics are sampled to less stringent criteria than major characteristics.

2-3.7.8 The Program Executive Officers have final approval authority for request for deviations (RFDs) and request for waivers (RFWs) regarding critical characteristics.

2-4 STATISTICAL PROCESS CONTROL (SPC)

2-4.1 Introduction. An integral part of statistical quality control is SPC which is the application of statistical principles and techniques for the purpose of processing data and providing feedback to aid in controlling, analyzing, and improving the process. The statistical analysis of data collected by sampling procedures provides objective evidence for attaining and maintaining process control. Such an application of sampling techniques is known as SPC. The tools most often used for SPC are the different types of control charts (i.e., those charts which pertain to the average and variability of a given measurable characteristic plus those charts which pertain to the rate of occurrence of defects or defectives). The prevention of, rather than the inspection for, nonconforming product is stressed by SPC. Continuous process capability improvement is an important part of SPC. As the process improves, quality improves, costs are reduced, and productivity is increased. Although a small initial investment is required, the application of SPC should result in higher quality products at a lower cost by reducing the cost of inspection, scrap, and rework. The application of SPC is, therefore, cost effective for both the Government and the contractor.

2-4.2 Establishing a SPC Program. Many excellent references and training courses are available which provide detailed instructions for implementing a SPC program. The key to successfully implementing a SPC program is not in the ability to produce technically accurate control charts but in the attitude and philosophy of the implementing organization. Basically, the contractor must possess the following elements in order to achieve a successful SPC program:

a. Awareness. An awareness of the benefits to be obtained by the organization through the implementation of SPC.

b. Upper Management Commitment and Involvement. The program must be accepted company wide. Upper management must realize that SPC is not a quick fix program and that they must make a life-long commitment to the program. They must learn and use the principles of SPC themselves.

c. Responsibility for the Program. During the start-up phase of the program, someone in the contractor's organization must be given full responsibility and authority for implementation. Eventually SPC should become institutionalized within the implementing organization, but until this occurs, someone must be held responsible for making it happen.

d. Top-Down Training. Training in SPC must be required for all organizational levels with the amount of training dependent upon the individual's responsibilities.

e. Technical Resource. The responsible organization should have access to someone skilled in the practical application of statistics.

f. Use of SPC by Operators. Data should be collected, plotted, interpreted, and acted on by the individual controlling the process.

g. Dynamic Program. As processes are analyzed, it should become apparent that some variables being plotted are not significant, and some variables not being plotted are significant. The program structure should provide for flexibility to allow for necessary changes.

h. Institutionalization. The use of statistical principles and techniques for improving quality must become a way of life for the contractor.

2-4.3 Principles of SPC.

2-4.3.1 Although this pamphlet does not provide a complete text on the subject of SPC, it does address certain basic principles that should aid a person in the understanding of the methods and advantages of conducting such procedures. Although SPC is most effective in high rate, production environments and when inspecting variables (measurement readout), it is also effective in low rate environments or when inspecting by attributes (go/no-go). It is most effective when applied to machine dominated (automated) processes where predictability is relatively high. Also, SPC is effective when applied to human dominated (manual) processes. All processes should be thoroughly analyzed by the contractor to determine if SPCs should be implemented.

2-4.3.2 The quality of a product can be controlled if future quality can be predicted on the basis of past experience. Since no two units of product have exactly the same quality measurements, the problem of control becomes the problem of predicting future quality within certain limits. In other words, the variation of a quality characteristic can be predicted, with reasonable confidence, to remain within stated limits.

2-4.3.3 Variations in manufactured items are inevitable, thus the idea of an exact repetitive operation is unrealistic. Since no two items are made exactly alike, one must think in terms that a characteristic does not differ from the standard by more than a certain amount.

2-4.3.4 The sources of variation in manufactured items are materials, machines, personnel, and manufacturing conditions. By means of SPC, the causes of variation may be separated into two types: chance (common) causes of variation and assignable (special) causes of variation. Variations in measurements tend to group about a center point (average or mean) in a manner such that most measurements in the population will occur near and equally on either side of the mean. Many processes will normally produce a population that, when graphed, will produce a bell-shaped curve. This is called normal distribution (Figure 2-4.1) where the measurement values (x) are distributed horizontally, and their frequency of occurrence (density) is graphed on the vertical axis. The center of the population is at X -BAR (\bar{x}).

2-4.3.5 Chance causes are those causes of variation which belong to a stable and predictable system or a process that is in control. If chance causes are the only causes influencing a process,

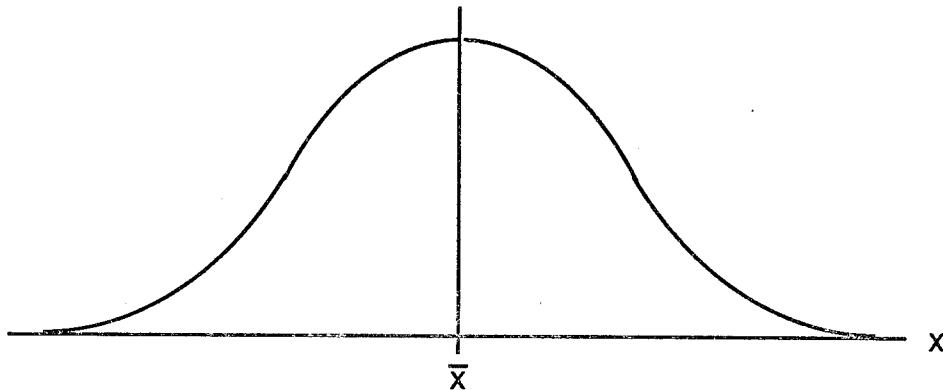


Figure 2-4.1 Shape of Normal Distribution

then the variability of the product should follow a constant pattern. Such a pattern can be used as a basis for predicting future variation. Chance causes of variation are random and are inherent to the process. If a process is operating with only chance causes and is producing unsatisfactory product, the process should be changed.

2-4.3.6 Assignable causes are those causes of variation which belong to an unstable system or a process that is out of control. Such causes of variation can often be identified and eliminated. Elimination of these causes of variation leaves only the chance causes and consequently a constant pattern of variability. To maintain a constant pattern of variability, the assignable causes must be identified and eliminated.

2-4.3.7 A controlled process offers many advantages such as less production, inspection, and rework/scrap cost, and greater customer satisfaction. In addition to these economic considerations, effective process controls enable the contractor to fulfill his responsibility of submitting to the Government a product that conforms to specifications. Less verification inspection by the Government will be required for material manufactured under effective process control procedures.

2-4.3.8 To summarize: If a process containing chance causes is in control but producing nonconforming product, the basic process must be changed. If a process containing assignable causes is out of control, it must be corrected by identifying and removing those causes. The separation of these two types of causes of variation is accomplished through the use of control charts.

2-4.3.9 A satisfactory control system involves not only the determination of whether a process is in control, but also whether the process is in control at an acceptable level with an acceptable amount of variation. A process which is in control may be producing material which does not conform to specification requirements. Thus, it is necessary to know the difference between specification limits and control limits. When statistical data indicates that the process is in control, a process capability analysis should be performed to determine if the process variations can meet specifications and, if not, to estimate the percent defective. Figure 2-4.2 illustrates a satisfactory control system or process where the center line of the process coincides with the center of the lower and upper specification limits (LSLs and USLs). Virtually all measurements should fall within the specification limits. The lower and upper control limits (LCLs and UCLs) are tighter

than the specification limits and are tightened as the process improves. This results in a continuous process improvement.

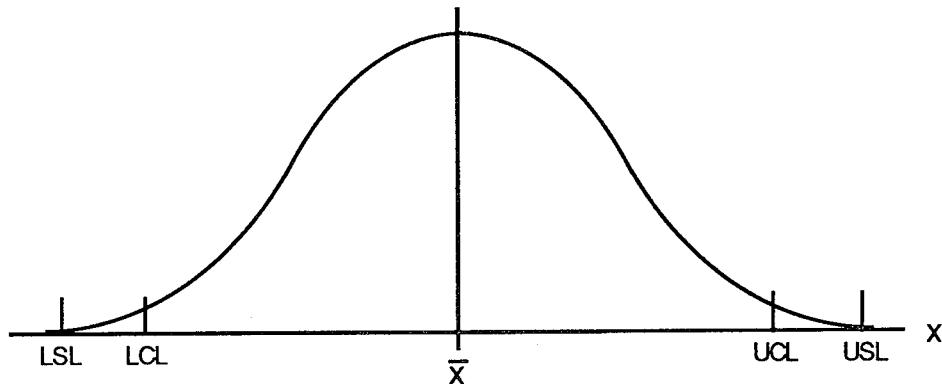


Figure 2-4.2 Satisfactory Process

2-4.3.10 The development and implementation of SPC begins after the process is satisfactorily designed and verified. This consists of analyzing the design of the process, identifying predictable assignable causes of variation, installing preventive maintenance procedures to eliminate assignable causes, exercising the process, screening the product, identifying and eliminating unpredicted assignable causes, and verifying that variations produced by chance causes are within acceptable limits (process capability). At this point, a capable process that is in control is in place. Maintaining process control, identifying the assignable causes, and making timely corrective action are the primary purposes of SPC.

2-4.3.11 The SPC methods basically consist of statistical sampling inspection of the product, documenting the inspection results, organizing and charting those results, analyzing the data, and identifying and eliminating assignable causes. Any nonconforming product is rejected, and the process is shutdown until corrected and verified.

2-4.3.12 The various tasks of SPC are conducted by such personnel as operators, inspectors, and production engineering. The operator which is at the heart of the procedure, inspects the sample, organizes and charts the data, and promptly notifies inspection and production engineering personnel when out of control conditions are indicated. In order to effectively accomplish these tasks, the operator must successfully complete a comprehensive SPC training program.

2-4.3.13 The presence of assignable causes of variation can be detected by comparing the actual statistical pattern of variation with the expected pattern of variation when only chance causes occur. The control chart is the tool used for this purpose.

2-4.4 The Control Chart.

2-4.4.1 The control chart is a device used to define the extent of process variability due to common causes and to detect the presence of assignable causes of variation. The actual identification and elimination of the assignable causes are the responsibility of production and engineering personnel. The chart shows when trouble exists but does not identify the trouble. Knowing the time when trouble occurs often helps in the identification of the problem. In addition, the control chart often gives a warning of impending difficulty. Steps should be taken to

investigate the situation and prevent the production of nonconforming products. Since the control chart gives a pictorial record of what is happening during the process, it allows the contractor to build quality into the product, which reduces the task of separating nonconforming material at final inspection. The theory and mechanics of constructing and interpreting control charts are beyond the scope of this pamphlet. However, some of their features and uses will be discussed briefly.

2-4.4.2 The control chart is a graphical record of the quality of production. It provides the average and variability of given measurable characteristics by a series of points plotted in sequence to the items produced. A control chart generally provides the features expressed in Figure 2-4.3.

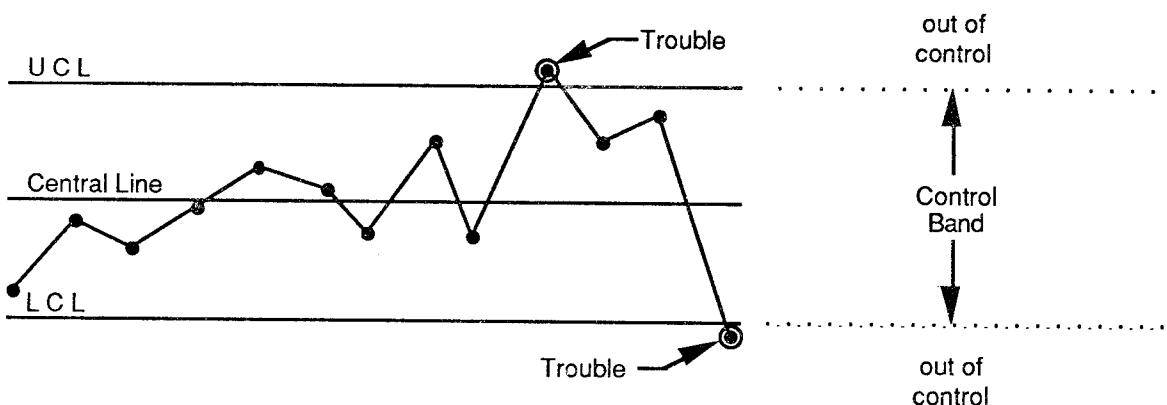


Figure 2-4.3 Features of a Control Chart

2-4.4.2.1 The central line of the control chart is the average measurement of a certain characteristic of a number of units of product. The actual measurement points tend to vary just above and below this line. The control limits are the mathematically derived limits of the process and are used to assist in judging the significance of the variations from the central line. Control limits are normally tighter than the specification limits of the product.

2-4.4.2.2 When only chance causes of variations are operating, the points fall inside the control band and the process is said to be "in control". Statistical control is established by the construction of control limits such that the occurrence of points outside these limits is regarded as cause for corrective action. Books on SPC control chart theory contain simple mathematical formulas and tables for computing the central and control limit lines.

2-4.4.3 The control limits:

- a. Aid in the determination of whether or not a state of control exists.
- b. Aid the contractor in attaining and maintaining control. When a control chart is first applied to a manufacturing process, a state of control usually has not yet been established. Control must be established before maximum efficiency in the operation can be obtained. This is accomplished by the elimination of all assignable causes of variation from the process. As stated above, quality must be built into the product, for it cannot be inspected into it.
- c. Aid in the detection of assignable causes of variation by providing criteria for discriminating between the causes of variation.
- d. Aid in determining when action is required on the process (assignable causes) and when it is not (chance causes).
- e. Are set at a point (normally ± 3 sigma) where virtually all of the population falls within the limits.

2-4.4.4 The advantages of a state of control are as follows:

- a. Minimizes variation between individual items.
- b. The quality of the product can be reliably judged by sampling.
- c. The proportion of product that lies within any given limits can be accurately predicted.
- d. The need for sampling inspection can be reduced, and the acceptance of product can be based on control charts.

2-4.4.5 The ideal process is one in which the process' central line coincides with the center of the specification limits, and in which all variations are equally distributed about the central line and fall well within the specification limits. Some examples of process distribution are shown in Figure 2-4.4. Features of production indicated by control charts are as follows:

- a. The consistency or regularity of performance is indicated by the position of points with respect to the control band and with respect to measurement point runs above and below the central line. A succession of random points inside the control band indicates a consistent process.
- b. The uniformity of product in terms of its basic variability.
- c. The average quality level of production.

2-4.5 Types of Control Charts.

2-4.5.1 There are two main types of control charts and these are dependent on the two principal types of data as follows:

- a. Control charts for variables (inspection by variables).
- b. Control charts for attributes (inspection by attributes).

2-4.5.2 Inspection is said to be by variables when a quality characteristic of the item is measured and recorded in units of measure such as pounds, feet, seconds, ohms, or feet per second.

2-4.5.3 Inspection is said to be by attributes when the item is classified as defective or nondefective with respect to a given specification.

2-4.5.4 The common control charts for variables are:

- a. Chart for averages.....(X-BAR chart).
- b. Chart for ranges.....(R chart).

2-4.5.5 The common control charts for attributes are:

- a. Chart for fraction defectives.....(p chart).
Ratio of the number of defectives to the number of items inspected.
- b. Chart for number defectives.....(np chart).
Number of defectives in the sample population.
- c. Chart for number of defects per sample.....(c chart).
Number of defects in the sample population.
- d. Chart for number of defects per unit.....(u chart).
Ratio of the number of defects in the sample population to the population number.

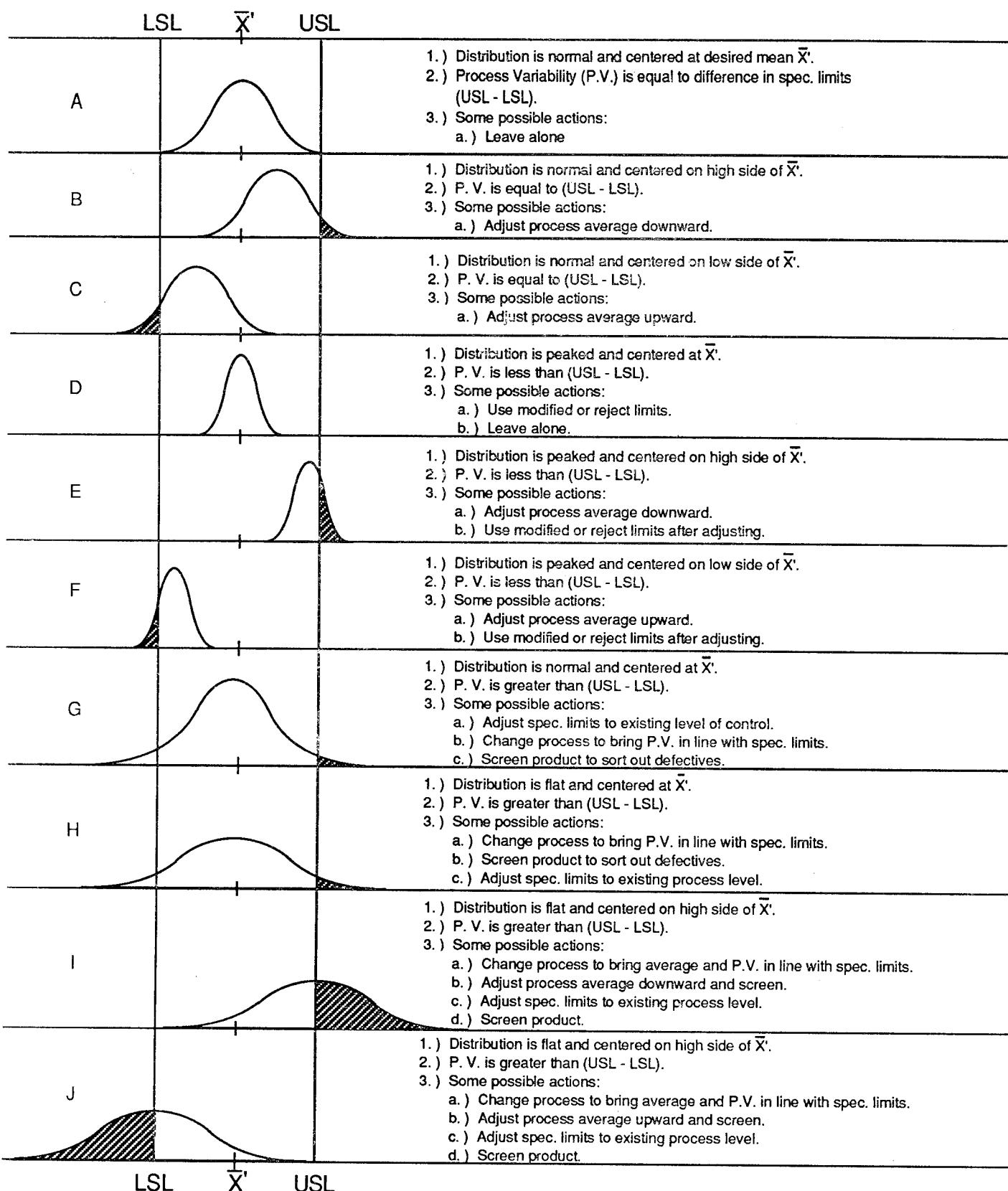


Figure 2-4.4 Some Possible Relationships Between Two-Sided Specification Limits and Natural Limits of the Process

2-4.5.6 Some of the advantages of variable charts are:

- a. Smaller sample sizes may provide equal information about a given characteristic.
- b. Trends regarding a given characteristic can be detected more quickly.
- c. They provide more information than attribute charts.

2-4.5.7 Some of the advantages of attribute charts are:

- a. Several characteristics/defects can be recorded on the same chart whereas variable charts address only one characteristic.
- b. Some characteristics cannot be measured as variables.
- c. Attribute charts require less measuring precision and less computational exercise.

2-4.6 Control Charts for Variables, X-BAR and R Charts.

2-4.6.1 Control charts for variables are designed to answer three important questions:

- a. Is the process consistent?
- b. What is the average quality of product?
- c. How variable is that quality?

2-4.6.2 The X-BAR chart provides information regarding the average quality. The R chart provides information regarding the variability. The two charts together provide reasonably good control of the entire process. An example of an X-BAR and R chart and the table of variables measurements from which it was constructed are shown in Figure 2-4.5.

2-4.7 Control Charts for Attributes.

2-4.7.1 Previous discussions of control charts have covered their application to measured values of quality characteristics. This section will cover inspection data from the classification of units as an "attribute", either good or bad. For example, the item inspected either conforms or does not conform, either passes or fails to pass (go or no-go gage), or either functions or fails to function to a given specification.

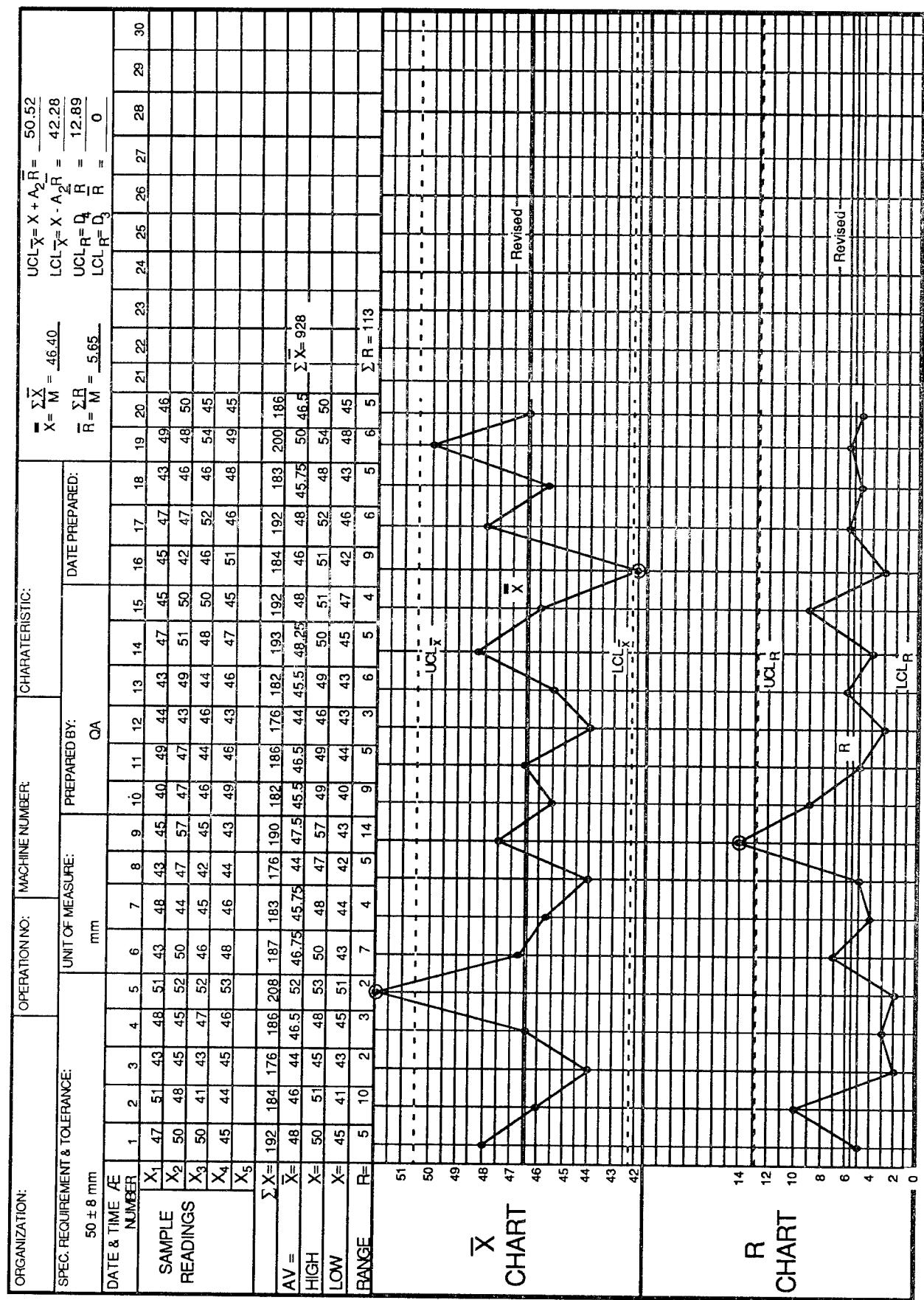
2-4.7.2 The results of such attribute inspections may be effectively used for the analysis of control. The quality of the process or product may be judged in terms of failure to meet the required standard in terms of defects or defectives. It is possible for a single item to contain many defects and still be counted as one defective when using attribute inspection.

2-4.7.3 Control charts provide a graphical record of quality by plotting the results of each inspection of a single quality characteristic or a group of characteristics.

2-4.7.4 Examples of attribute charts are illustrated in Figures 2-4.6, 2-4.7, and 2-4.8. The construction and interpretation of the charts will not be addressed in this pamphlet.

2-4.8 Analysis of Charting Patterns. Patterns that might be observed on control charts are as follows:

- a. Trends.
- b. Cycles.
- c. Sudden change in level.
- d. Natural or random patterns.

 \bar{X} AND R DATA SHEETFigure 2-4-5 \bar{X} and R Chart

NOTE: The p-chart can be converted to an np-chart, in cases where the sample size is constant, by altering the scale and multiplying the central line and control limits by 100. The p-chart and np-chart are equivalent.

Figure 2-4.6 Attributes Data Sheet and p-Chart

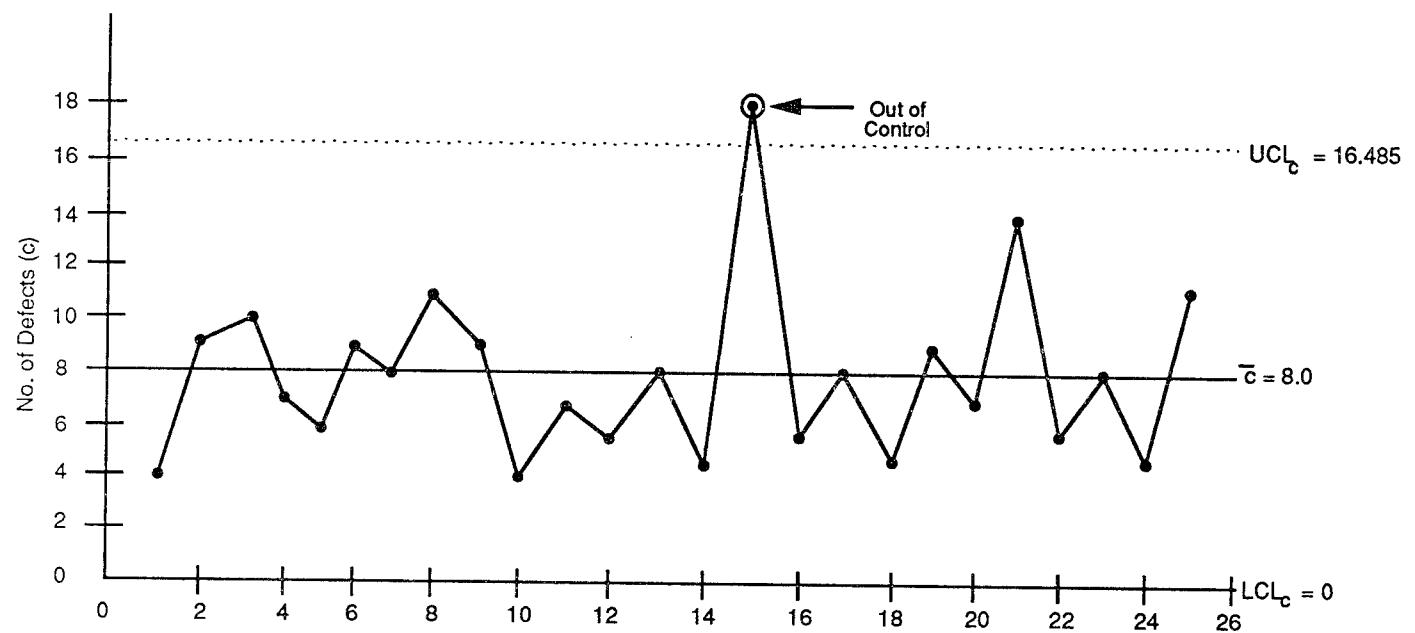


Figure 2-4.7 c-Chart

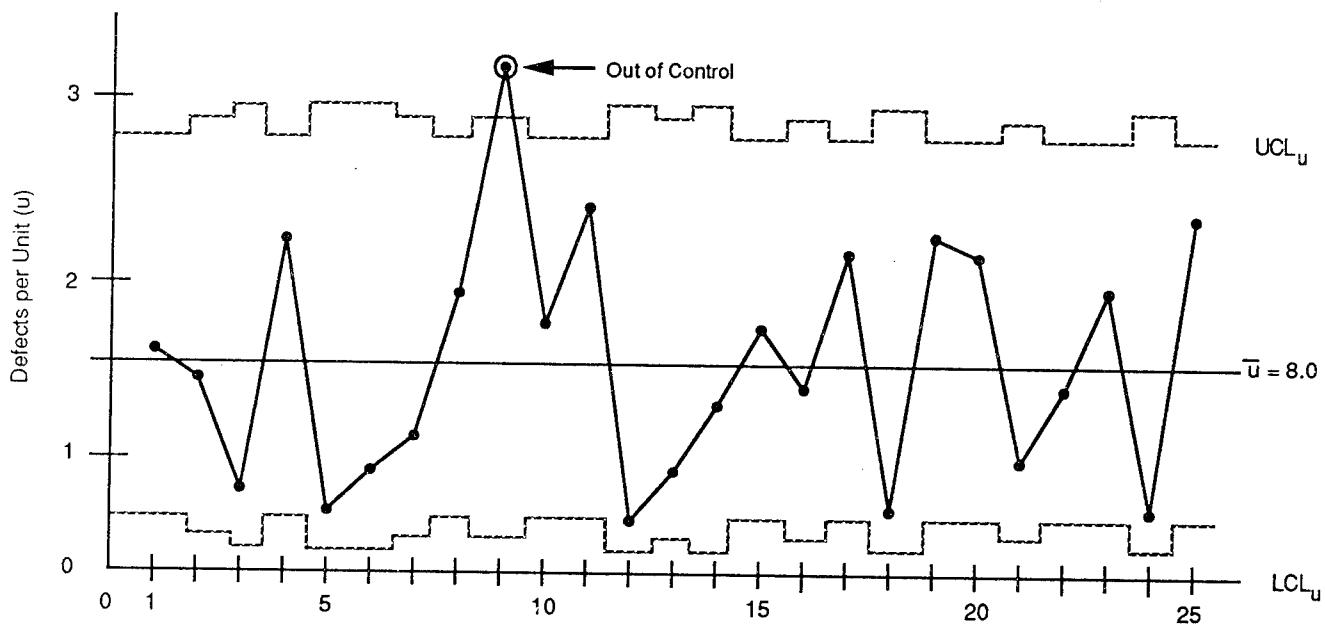


Figure 2-4.8 u-Chart

2-4.9 Trends.

2-4.9.1 A trend is a movement of points in one direction (up or down). Trends may occur as a series of consecutive points without change in direction (Figure 2-4.9) or as a gradual change in direction with some up and down movement (Figure 2-4.10).

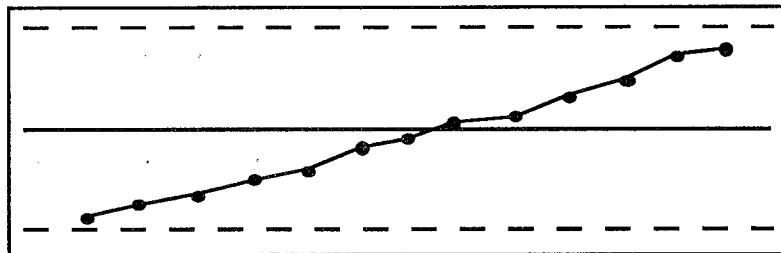


Figure 2-4.9 Trend Upward

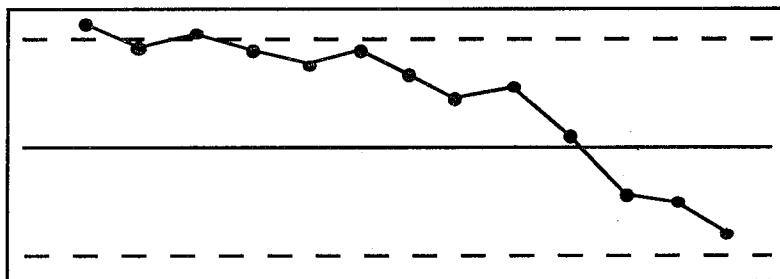


Figure 2-4.10 Trend Downward

2-4.9.2 Trends on the X-BAR chart mean that the center of the distribution is changing. Trends on the R chart mean that the spread or variation is changing. Trends on the p chart mean that the fraction defective is changing. Care should be taken in denoting trends because it is easy to indicate a trend where none actually exists. Up and down fluctuations in a natural pattern may often appear as trends.

2-4.9.3 Some frequent causes of trends, listed according to the type of chart, are as follows:

- a. X-BAR chart (R chart must be in control)
 - (1) Tool wear.
 - (2) Wear of threads, holding devices, or gages.
 - (3) Operator fatigue.
 - (4) Changes in production schedule.
- b. R chart
 - (1) Increasing trend:
 - (a) Gradual loosening or wearing of a tool or machine part.
 - (b) Dulling of a tool.
 - (2) Decreasing trend:
 - (a) Gradual improvement of operator technique.
 - (b) Better maintenance program.
 - (c) Other process controls which gradually increase uniformity.

c. p chart

(1) Trend upward. The process is turning out more defectives, which may be due to:

- (a) Introduction of lower quality material.
- (b) Inadequate work by operators.
- (c) Tool wear.
- (d) Tightening or addition of quality requirements or standards.

(2) Trend downward. The process is turning out fewer defectives, which may be due to:

- (a) Introduction of better quality material or tools.
- (b) Increasing improvement of operator.
- (c) Relaxation of requirements or standards.

2-4.9.4 The difference between a trend and a gradual change in level is that a trend has a tendency not to stabilize, whereas a gradual change tends to settle at a new level. A gradual change in level, with the change occurring generally in the direction of improvement, is very common in the early stages of a quality program.

2-4.10 Cycles.

2-4.10.1 Short trends in data which show a tendency for repeated patterns are nonrandom and are known as cycles. Cycles may be identified by determining the time interval at which successive positive or negative peaks appear and relating this time to the process (Figure 2-4.11).

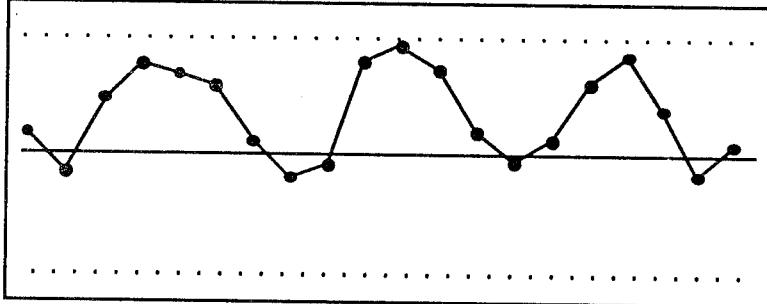


Figure 2-4.11 Cycle

2-4.10.2 One common cause of cycles is the variation in the operator's technique or mood during different periods (beginning or end of the week, before or after lunch or rest periods, at shift changes). Other causes of cycles are as follows:

- a. X-BAR chart (R chart must be in control)
 - (1) Effects of temperature and humidity.
 - (2) Job rotation.
 - (3) Operator fatigue.
 - (4) Fluctuations in voltage.
- b. R chart
 - (1) Regular maintenance schedules.
 - (2) Wear of tool or die.
- c. p chart
 - (1) Variations in sampling practices.

(2) Differences in supplier's material.

2-4.11 Sudden Change in Level.

2-4.11.1 A sudden change in level may occur as a result of a sudden change in one direction (Figure 2-4.12).

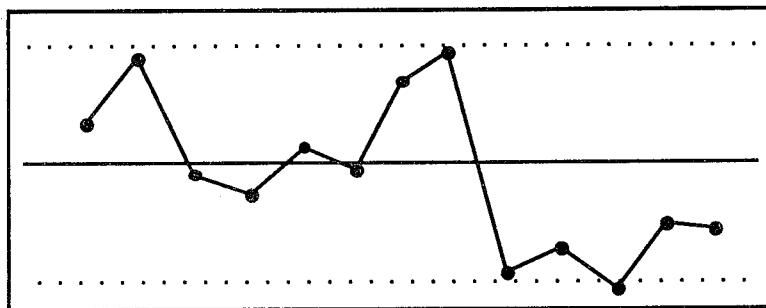


Figure 2-4.12 Sudden Change in Level

2-4.11.2 Causes of sudden changes in level:

- a. X-BAR chart (R chart must be in control)
 - (1) Change of material.
 - (2) Change of operator.
 - (3) Change of inspector.
 - (4) Change of machine or machine setting.
 - (5) Change in set-up or method.
- b. R chart
 - (1) Change of operator, operator technique, or equipment.
 - (2) Change of supplier or material.
 - (3) Inadequate maintenance (increase variation).
- c. p chart
 - (1) Change of material.
 - (2) Change of machine or operator.
 - (3) Change in calibration of the IE.
 - (4) Change in method.
 - (5) Change in standards.

2-4.12 Natural or Random Pattern.

2-4.12.1 Up to this point, several of the unnatural or nonrandom points and patterns have been discussed. It may be wise to point out what constitutes a natural or random pattern. A natural pattern is stable over a long series of plotted points with no trends, sudden shifts, nor erratic movements. However, stability alone is not sufficient for calling a pattern natural.

2-4.12.2 In a natural pattern, points fluctuate at random and obey the laws of chance. Most sampling distributions found in quality control tend to be symmetrically shaped (normal) about the mean. Therefore, it is natural for the number of points on one side of the control chart's central line to be approximately equal to the number on the other side, with the majority of points near the central line.

2-4.12.3 Earlier in this section the control limits (Figure 2-4.3) were discussed and from an earlier study of the normal distribution (Figure 2-4.2), it was found that control limits cover virtually all of the values about the mean. In other words, if the process is in control, it is very rare for a point to fall outside the control limits.

2-4.12.4 In summary, a natural pattern has the following characteristics:

- a. Most of the points will be near the control chart's central line.
- b. Some of the points will spread out and approach the control limits.
- c. It is a rare occurrence when a point exceeds the control limits.
- d. There should be approximately an equal number of points on each side of the central line.

2-4.13 Implementing SPC

2-4.13.1 The SPC procedures should be instituted at the outset of the initial production effort required during the Engineering and Manufacturing Development phase of the life cycle and maintained throughout the Production-Deployment phase. In order to accomplish this, intensive planning must take place during the development period and prior to initial production.

2-4.13.2 As processes are developed, each one should be examined to determine if SPC will be effective. The processes selected for SPC should undergo process capability analysis. Tools such as IE, tables, charts, and operator instructions must be developed and put in place. Personnel must be trained. Authority to conduct the program and shut down out-of-control processes should be delegated. A detailed plan addressing all aspects of the SPC program must be generated, approved, and implemented. These and other required actions must take place in a timely manner to insure that SPC procedures are in place and ready to operate at the beginning of production.

2-4.13.3 When production begins, product conformance is assured by 100% inspection as data is accumulated to verify process capabilities. When there is confidence that a process is in control and capable of producing conforming product, 100% inspection can then give way to that degree of statistical sampling required to effectively monitor the process. The process must then be continuously monitored throughout production to detect assignable causes and, through timely failure analysis and corrective action, eliminate them. If necessary, the process must be shut down and the affected product screened.

2-5 ENVIRONMENTAL STRESS SCREENING (ESS)

2-5.1 In the past, there was a high degree of skepticism and reluctance among contractor and Government personnel regarding ESS. ESS is now, however, receiving much greater acceptance from both Government and industry. The skepticism and reluctance were no doubt the result of a lack of knowledge of what ESS is, what it does, and how it is to be implemented. It is a powerful quality control tool used to precipitate latent defects. It is not a test nor a demonstration and was never intended to be used to accept or reject product. The product is exposed to nondestructive stress conditions that reveal otherwise undetectable weaknesses and defects, thus providing an opportunity for lower cost repair and timely corrective action. The ESS program is to be implemented by knowledgeable personnel who are capable of designing a program and tailoring it to a specific product. The program should provide the screens necessary to precipitate the defects inherent in the product without exceeding design limits or fatiguing the product.

2-5.2 In the 1950's, ESS was instituted in the space industry and was applied to some electronic and electromechanical systems of that day. Gradually, ESS spread into the aerospace, military, and commercial industries. Early procedures were relatively primitive, employing such techniques as pendulum swing and hammer drop impacts with little idea of the actual stress being

imparted. The missile and space programs of the 1960's did much to advance the state of the art that led to the sophisticated equipment and techniques utilized today.

2-5.3 Some of the misconceptions that impeded the acceptance of the ESS concept and the facts relating to them are as follows:

- a. Misconception: ESS is not cost effective.

Fact: ESS is very cost effective in the same manner that SPC is. The front end cost is more than offset by reduced cost of repair, warranty replacement, rejected material, field failure rates, and customer dissatisfaction.

- b. Misconception: ESS damages equipment or shortens its life.

Fact: Properly designed and conducted ESS processes will not damage defect-free equipment and will not materially use up its life. Only those screens effective in precipitating latent defects and those levels approaching, but not exceeding, the design limits are to be employed.

- c. Misconception: ESS is overkill since it reveals design problems which have already been verified by design testing.

Fact: ESS rarely uncovers design problems during production in those cases where an effective ESS program had been conducted during development. It is structured to detect material and manufacturing problems.

- d. Misconception: ESS is not needed for equipment built with burned-in components.

Fact: ESS is designed to precipitate component failures as well as to precipitate latent defects resulting from flawed assembly processes. If ESS is properly applied at sequential stages of the assembly, it should perform this task. When these screens are properly designed, only weak or defective components will fail.

- e. Misconception: If there are few or no precipitated failures, all processes may be considered adequate, and ESS can be discontinued.

Fact: Few or no failures may verify that the processes are adequate but is more likely to verify that the screens are ineffective. Such a condition merits careful analysis of the screens and, where evidence verifies satisfactory processes, the number of items undergoing ESS may be reduced but never discontinued.

2-5.4 Very few guidelines for ESS were available until the Institute of Environmental Sciences published guidelines for stress screening in 1981, 1984, 1985, and 1988. These guidelines can be a valuable aid in designing and implementing an ESS program. There are no generic ESS programs. Each program must be designed and conducted specifically for the product to be screened. In order to accomplish this, an intense analysis of the design, design limits, operating limits, failure modes, inherent defects, and manufacturing processes of the product must be performed.

2-5.5 Although there are many stress mechanisms used in stress screening, experience has shown that only a few are truly effective for most products. These are high temperature, temperature cycling, random or complex wave form vibration, power cycling, and voltage stressing. Temperature cycling and vibration are the most effective screens for electronic equipment along with power cycling for some types. Temperature cycling and vibration seem to be the most effective screens for mechanical and electromechanical equipment.

2-5.6 An ESS program that involves the detection and repair of latent defects without failure analysis nor corrective action is just another inspection procedure. The ESS process is more than just another inspection procedure. It should be thought of as a process improvement function in that it detects otherwise undetectable defects caused by flawed manufacturing processes. This

leads to the examination and correction of the process. Failure reporting, analyses, and corrective action must be an integral part of any ESS program for it to be effective.

2-5.7 The need for ESS is dictated by the difficulty in detecting many types of latent defects. When properly applied, the stresses provided by ESS will elevate the defect to the point where it can be detected by conventional inspection methods and removed prior to delivery. Early corrective action can then be taken to remove the flaw that caused the defect.

2-5.8 Complex manufacturing processes consist of many operations that carry a high potential for flaws or errors. Processes used in the production of similar types of equipment tend to be similar themselves and are susceptible to the same types of flaws. Experience has led to the identification of many of these flaws. Table 2-5.1 lists some operations that are involved in the production of printed wiring assemblies (PWAs) and some defects commonly encountered that can possibly escape early detection. Knowledge of these potential defects can aid in the design of effective screens. Table 2-5.2 lists typical defects detected during the ESS of PWAs and the screens most likely to precipitate them. Since the selection and design of screens are to a large extent empirical, the screening data should be continuously recorded, organized, monitored, and evaluated so that the screens may be modified as needed. If the stresses are not severe enough, latent defects will not be accelerated and the process will not be effective. If the stresses are too severe, the product will be damaged. Maintaining a balance between the two can be challenging but greatly aided by proper data collection and analyses.

2-5.9 In designing and implementing an ESS program, a common mistake is to attempt to repeat what others are doing. While there are only a few stresses to consider, there are sufficient differences in product designs and technology to require that the screens be tailored to the product. Specific screens or screen combinations should be designed to address the more prevalent failure mechanisms.

2-5.10 Demonstrations have proved that ESS is a cost effective concept that greatly enhances the quality of the product in the field. A ten percent cost increase in the front end of a program often delivers a cost savings over the life of the system many times in excess of the increase. The key to a successful ESS program is to understand the cause of failures. Most of what is wrong with a product can be found by analyzing the defectives. The cause of system failures is usually due to latent defects which are the target of ESS.

2-5.11 In summary, there must be a willingness on the part of management to make an up front investment. Once the decision is made and the ESS program initiated, there must be a way to assess the progress being made, and a means of gaging the effectiveness of the screen. Finally, the effort must have staying power. The program must be allowed to proceed through the complete cycle of experimentation, implementation, data acquisition and analysis, and optimization. Managers are apt to be very uneasy during the early stages before the process is clearly understood, but the long term gains in customer satisfaction and life cycle cost savings will be well received.

2-6 CRITICAL SAFETY ITEM (CSI) PROGRAM.

2-6.1 Introduction.

2-6.1.1 In 1985, AMC directed its subordinate commands to institute a program that assures the identification, validation, technical description, and control of all critical safety characteristics, CSIs, and critical safety manufacturing/assembly processes. The program is to provide intensive management and control of these characteristics, items, and processes throughout the life cycle of

TABLE 2-5.1
Potential Defects Introduced
During Manufacturing Process

Step No.	Operation	Potential Defects
1	Parts selection and kitting	Wrong part Damaged part
2	Parts insertion	Damaged lead Damaged part Damaged PCB Contamination
3	Lead trimming	Damaged lead Lead too long Damaged PCB
4	PCB cleaning	Contamination Damaged part Damaged PCB
5	Flux application	Contamination Damaged part Damaged PCB
6	Soldering	Cold solder joint Solder bridging Thermal damage to part Thermal damage to PCB
7	Cleaning	Contamination Damaged part Damaged PCB
8	Conformal coating	Contamination Damaged part Damaged PCB
9	Assembly test	Damaged part Electrical overstress
10	Final inspection and test	Damaged part Damaged PCB Electrical overstress

TABLE 2-5.2
Typical Defects Detected
During Environmental Screening

Defect Type	Environment at Detection	
	Thermal Cycling	Vibration
Parameter drift	X	
PCB shorts and opens	X	X
Wiring harness connections		X
Part incorrectly installed	X	X
Wrong part	X	
Hermetic seal failure	X	
Contaminated part	X	
Foreign material contamination	X	X
Chafed wires		X
Pinched wires		X
Loose wires		X
Adjacent parts shorting		X
Adjacent boards touching		X
Parts not bonded down		X
Loose parts		X
Cold solder joints	X	X
Loose hardware		X
Defective parts	X	X
Loose fasteners		X
Improperly mated connectors		X

PCB - Printed Circuit Board

the CSI. The program is applicable to the development and procurement activities, prime contractor, subcontractors, suppliers, test and support activities, overhaul and maintenance activities, and storage surveillance activities. AMC Regulation 702-32, which outlined the CSI program and its requirements, was implemented in January 1986 and was followed by MICOM Policy 702-18 in May 1986.

2-6.1.2 PAD was assigned the lead role for MICOM in establishing and implementing the program to include all assigned weapon systems, directly procured spares, support hardware and software. A MICOM CSI committee was formed in 1986 to oversee the program, with the chief of the QE Division, PAD serving as chairman, and consisting of members from the Safety Office, the System Engineering and Production Directorate, the MICOM Test and Evaluation Management Office, and the Missile Logistics Center. The various project offices and the Weapon Systems Management Directorate provide members to this committee for their assigned systems.

2-6.2 Definitions.

2-6.2.1 Critical Safety Characteristic: Any feature of a product including materials and processes which, when nonconforming or missing, would likely result in the failure or malfunction of the CSI and create a personnel hazard or system loss. A hazard is a prerequisite to an unplanned event or series of events that results in death, severe injury, or severe occupational illness.

2-6.2.2 Critical Safety Item (CSI): Any item whose failure or malfunction would result in an event which could cause death, severe injury, or system loss. This definition includes items used in the fabrication/assembly of warheads, rocket motors, fuses, safety and arming devices, and other devices used in a missile propulsion/detonation chain. Also included are fin and wing deployment and control devices, self-destruct mechanisms, vehicle steering and braking systems, lifting and hoisting devices, and possibly other system unique items. A CSI is any item that contains a critical safety characteristic.

2-6.2.3 Critical Safety Process: Any process which, if improperly performed, may cause death, severe injury to personnel, or system loss. This includes certain processes such as heat treating, welding, riveting, fabrication of warhead and rocket motor cases, propulsion system manufacturing, and propellant loading.

2-6.2.4 System Loss: System loss occurs when the system either becomes permanently disabled while in a tactical situation or is destroyed due to internal system malfunctions. Some examples include premature warhead detonations prior to minimum arming distance, ignition of missile flight motors due to stray electrical currents, and explosions resulting from ignition of volatile substances. Flight failures after missile launch are excluded except in cases where personnel safety or range boundaries are threatened.

2-6.3 Program Structure.

2-6.3.1 The overall effort required to develop and implement a successful CSI program can be categorized into three phases as follows:

- a. Identification and documentation of critical safety characteristics, items, and processes.
- b. Validation of the requirements relative to the characteristics, items, and processes.

c. Establishment and implementation of effective controls that will assure conformance to safety related requirements during the development, production, repair, overhaul, rebuild, storage, and field maintenance stages.

2-6.3.2 The process of identification, validation, technical description, and control of CSIs is a total system life cycle activity that begins with the description of an operational system requirement. The most significant accomplishment during this phase is to have management from both industry and Government recognize the need to implement a program for CSI identification and control. Since a CSI will generally remain as such throughout its life cycle, this program must address identification and control beginning with the development phase and continuing through final disposal. This requires that adequate knowledge and recognition of CSIs must be maintained throughout the design, purchasing, manufacturing, transportation, repair/overhaul, maintenance, and any other related activity.

2-6.3.3 Contractors will be required to establish, implement, and document an effective CSI program which will assure that CSIs are identified, controlled, and verified as conforming to specification requirements. This program will provide additional emphasis to critical safety parts and is not intended to replace, delete, nor minimize any other contractual quality requirement. The following elements should be addressed by the contractor's CSI program:

a. The classification of a CSI must be based on sound engineering judgment relating to the effect on safety and documented in failure modes, effects, and criticality analyses. The application of the item and the safety aspects of the end item mission must be considered when making the critical classification determination. The CSI program must identify all items that are truly critical. The program should not be diluted with factors such as processing costs, schedules, or even loss of or severe damage to equipment, unless it would result in a hazard to personnel or in the loss of a system.

b. Each CSI and critical safety process must be clearly identified as such on the engineering drawing, safety assembly drawing, or in the specification, whichever is applicable. The drawing or specification must also identify all critical safety characteristics of that item. The requirements for marking CSI drawings are provided in DOD-STD-100. An example is shown in Figure 2-6.1. Overhaul/repair procedures and maintenance manuals must provide the same identification techniques.

c. A CSI/critical safety characteristics list must be initiated during early development and expanded as necessary through production. This list will be dynamic in nature, with changes taking place as experience and knowledge are obtained and design changes incorporated. This list and all subsequent changes to the list are to be supplied to the Government. In the event that a normal development program is not required such as on nondevelopmental items, it is essential that this list be supplied early in the initial production phase.

d. The requirements affecting CSIs must be validated to insure that all critical aspects of the design are accurately reflected, that parts and materials operate well below fatigue limits/stress levels, and that the design allows for assessment by inspection and nondestructive IE. Validation must be based on engineering analysis of the critical safety characteristics and should consider changes/deterioration through time or use, fatigue life, and operating conditions. Stress/strength, fracture mechanics, structural integrity, worst case tolerance, sneak circuit analyses, and thermal surveys, as appropriate, will be used to validate the design requirements.

e. The contractor's CSI program should be controlled by a high level control board composed of personnel from the design, quality, manufacturing, field service, engineering, safety, and other appropriate departments. This board will function similarly to a configuration control board (CCB), reviewing and formally approving all aspects of the CSI program. It is essential that the responsibilities of the board be clearly defined and a single organizational element be assigned overall responsibility for the program.

f. Each manufacturing or assembly process that produces a critical safety characteristic must be controlled by detailed procedures outlining each step or parameter of the process along with any tooling, equipment, or operator certification requirements. These procedures will, as a minimum, be reviewed and approved by the contractor's engineering, manufacturing, and quality

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PORTIONS OMITTED FOR SIMPLICITY									
4 QUALITY ASSURANCE PROVISIONS:									
A UNLESS OTHERWISE SPECIFIED IN THE CONTRACT, THE CONTRACTOR IS RESPONSIBLE FOR THE PERFORMANCE OF ALL INSPECTION REQUIREMENTS AS SPECIFIED HEREIN.									
B QUALITY CONFORMANCE INSPECTION SHALL BE IN ACCORDANCE WITH TABLE 1 AND NOTES OF THIS DRAWING.									
C SAMPLING INSPECTION SHALL BE IN ACCORDANCE WITH MIL-STD-105.									
D ALL OTHER CHARACTERISTICS ARE SUBJECT TO INSPECTION UNDER THE CONTRACTORS QUALITY OR INSPECTION SYSTEM.									
E A FIRST ARTICLE SAMPLE IS REQUIRED WHEN SPECIFIED IN THE CONTRACT. ACCEPTANCE WILL BE BASED ON CONFORMANCE TO THE REQUIREMENTS OF THIS DRAWING.									
5 CRITICAL SAFETY CHARACTERISTICS ARE INDICATED 									
6 SQUIB RESISTANCE: WARNING - HAZARDOUS OPERATION									
THIS OPERATION IS CONSIDERED HAZARDOUS. THE MEASUREMENTS SHALL BE MADE WITH ALL APPLICABLE SAFETY PROCEDURES OBSERVED. AFTER INSTALLATION OF ITEM 5, CHECK THE PARALLEL CIRCUIT RESISTANCE OF THE SQUIB USING AN UNGROUNDED OHMMETER WITH TEST CURRENT LIMITED TO 10 MILLIAMPERES. RESISTANCE TO BE 0.11 TO 0.21 OHMS.									
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elements. Once approved, these procedures and sequence of operations cannot be changed without the approval of these three elements. Procedures may be documented in a variety of formats. However, all operations producing critical safety characteristics must be clearly identified and defined. In all cases, the procedures will provide a format for the operator to verify and record the date that the operation was completed. When the characteristic is to be produced by a subcontractor, the controlling procedures and all changes thereto must be reviewed and approved by the prime contractor.

g. All critical safety characteristics which can be nondestructively inspected will undergo 100 percent inspection by either the prime contractor or the vendor's quality department. For vendor produced parts, the prime contractor will exercise a level of inspection which assures product compliance to requirements. The inspection personnel will be required to be certified for the inspection of critical characteristics/processes. It is the quality organization's responsibility to assure that any required destructive testing is conducted. All inspection records must identify each specific critical safety characteristic inspected and reflect the results of inspection, date of inspection, identity of the inspector, and any required inspector certification. The quality organization is also responsible for performing periodic audits of manufacturing/assembly areas to assure that adequate process controls are in place and are in compliance with CSI program requirements.

h. The vendor's quality program must address controls for CSI/critical safety characteristics and contain a requirement for the periodic auditing of the implementation of these controls.

i. All technical/quality requirements relating to CSIs must be traceable to the time and place that the items were produced. Records will provide the degree of traceability required to enable after the fact verification of all aspects of material, manufacture, special processing, assembly, and inspection of critical safety characteristics.

2-6.3.4 Several organizational elements within MICOM play an important role in the formulation and implementation of a CSI program. However, PAD has the overall responsibility to provide management control for the program and to assure that the identification and control of the CSIs are maintained throughout all phases of their life cycle. It is also PAD's responsibility to maintain current lists of CSIs, to approve break-out decisions, and to assure that any item identified as the cause of an accident is on the CSI list for similar systems. PAD also has the responsibility to conduct periodic hardware oriented audits at both manufacturing and maintenance facilities to assure that the CSI program is properly implemented and controlled.

2-6.3.5 Since all CSIs must be qualified, the qualification requirements for new producers and for design changes must be established prior to full-scale production. Whenever there are changes in producers or in the design, the same level of qualification required of the original component configuration must be applied. In this case, qualification by similarity of processes, materials, or stated performance is not sufficient.

2-6.3.6 The CSIs require intensified quality inspection and verification by the contractor. Letters of instruction to the contractor must provide detailed requirements to assure that the CSI lists are current, and that the CSIs are adequately controlled and IAW technical requirements. The requirements for intensified inspection and verification must be extended to the agencies performing Government source inspection at vendor facilities.

2-6.3.7 When CSIs remain safety critical throughout the system's life cycle, it is essential that identification and special processing requirements be maintained through overhaul/repair and field maintenance. Overhaul/repair procedures, technical manuals, DMWRs, and other applicable work instructions/bulletins must identify CSIs. The documents must provide in detail the special process requirements, tolerances, fits, wear limits, approved overhaul/repair criteria, inspection, and functional test requirements. Depot processing of CSIs must be accomplished with the same degree of controlled conditions, to include detailed work instructions, as were required during the

original manufacturing. A QA letter of instruction to the depots must provide them with detailed instructions regarding more intensified inspections and verifications.

2-6.3.8 Quality deficiency reports regarding CSIs must be given immediate attention to determine if additional actions are required due to safety considerations. Procedures must be implemented to provide for the matching of the CSI list with deficiency reports immediately upon their receipt.

2-6.3.9 The CSIs must be adequately identified prior to break out procurement so that the means of assuring that manufacturing/quality controls can be maintained. The procedures must be in place so that the Government can assure that the integrity of the item can be maintained prior to making a break-out decision. The Government must be prepared to review/approve suppliers to assure that the manufacturing and assembly qualification testing will be performed, and that all special processing/quality requirements will be continued.

2-6.3.10 The CSI program excludes ammunition, nuclear warheads, and defensive chemical materiel only to the extent that such safety requirements are excluded and/or limited by Army Regulation (AR) 702-6 and AMC-R 10-80.

2-7 ELECTROSTATIC DISCHARGE (ESD) SENSITIVE DEVICE CONTROL

2-7.1 Introduction

2-7.1.1 Various segments of industry have become aware of the damage that static electricity imposes on metal oxide semiconductors. Sensitivity of parts other than metal oxide semiconductors to an ESD has more recently become evident through use, test, and failure analysis of the parts. Trends in technology toward greater complexity and increased packaging density results in thinner dielectrics between active elements which, in turn, results in parts becoming more sensitive to ESD. The construction and design features of current microtechnology have resulted in parts which can be destroyed or damaged by ESD voltages as low as 20 volts.

2-7.1.2 Various electrical and electronic parts, which have been determined to be sensitive to electrostatic voltage levels commonly generated by production, test, operation, and maintenance personnel, include microelectronic and semiconductor devices (thick and thin film resistors, chips, and hybrid devices) and piezoelectric crystals. Subassemblies, assemblies, and equipment containing these parts that do not have adequate protective circuitry are also ESD sensitive. Materials that are prime generators of electrostatic voltages include common plastics such as polyethylene, vinyls, foam, polyurethane, synthetic textiles, fiberglass, glass, rubber, and numerous other commonly used materials. Actions which cause these and other materials to generate electrostatic voltages are sliding, rubbing, and separation. These actions can result in electrostatic voltages as high as 15,000 volts.

2-7.1.3 Protection of electrical and electronic ESD sensitive parts, assemblies, and equipment (collectively referred to herein as items) can be provided through the implementation of inexpensive ESD controls, of which many have been used in the ordnance industry for decades. The lack of ESD controls has resulted in high repair costs and excessive equipment downtime and has reduced mission effectiveness. This situation has contributed to items being damaged during processing, assembly, inspection, handling, packaging, shipping, storage, testing, installation, and maintenance throughout their life cycle at both contractor and Government facilities.

2-7.1.4 The effects of an ESD on electrical and electronic items are often not recognized for the following reasons:

- a. Failures due to an ESD are often analyzed as having been caused by electrical overstress due to transients.
- b. Failures due to an ESD are often incorrectly categorized as random, unknown, infant mortality, manufacturing, or other defects due to improper failure analysis.
- c. Many laboratories lack the proper equipment such as scanning electron microscopes or the proper technology to trace failures to an ESD.
- d. Some manufacturers accept high operational failure rates as normal.
- e. The mistaken belief that static controls are necessary only for metal oxide semiconductors at the manufacturer's site and for the handling of ordnance.
- f. The mistaken belief that an ESD sensitive part protected by a diode, resistive network, or other protective techniques is no longer ESD sensitive.
- g. Static discharge failures may not occur immediately after exposure but may emerge as a latent defect.

2-7.2 Nature of Static Electricity.

2-7.2.1 Static electricity is an electrical charge at rest. The electrical charge is due to the transfer of electrons within a body (polarization) or from one body to another (conductive charging). The transfer occurs due to the interaction of charged bodies or to the interaction of charged bodies with uncharged bodies. The magnitude of the charge is primarily dependent on the size, shape, composition, and electrical properties of the substances which make up the bodies. Some substances readily give up electrons while others tend to accumulate excess electrons. A body with an excessive number of electrons is charged negatively while a body with an electron deficit is charged positively. When two substances are rubbed together and then separated or when substances flow relative to one another such as a gas or liquid over a solid, one substance gains electrons and the other loses electrons. These electron charges are equal and, in the case of nonconductors, tend to remain in the localized area of contact. Charges on conductors, however, are rapidly distributed over its surface and the surfaces of other conductive objects it comes in contact with. An electrostatic field (lines of force) exists between a charged body and a body at a different electrostatic potential such as a body with either more or less electron charges. Conductive and resistive bodies that enter this field will be polarized by induction even without contacting the charged body. In conductive bodies, electrons that are closest to the negative part of the field are repelled, leaving that area positively charged. The electrons that are attracted to the positive part of the field create negative and positive charged areas, but the net charge on the body remains zero. If a conductive polarized body is grounded, electrons will flow towards the ground, and the body becomes charged by the excess or deficit of electrons. Even though electrons are less mobile in a nonconductive body, dipoles tend to align with the field, thereby creating surface charges. A nonconductor cannot be inductively charged.

2-7.2.2 The capacitance of a charged body relative to another body or ground has an effect on the electrostatic field. When capacitance is reduced for a given charge, there is an inverse linear increase in voltage. As the capacitance is continually decreased, the voltage will increase until a discharge occurs via an arc. For example, when common polyethylene bags lying on a bench rub together, the charge potential may be only a few hundred volts, but when picked up by an operator, the voltage may be several thousand volts. This increase in voltage is due to the decrease in capacitance.

2-7.3 Triboelectric series. The triboelectric effect is the generation of static electricity when two substances rub together. A triboelectric series is a list of positive to negative charged substances resulting from the triboelectric effect. A substance higher on the list is positively charged when rubbed with a substance that is lower on the list because more free electrons exist on the substances higher on the list. Electrons from substances higher on the list are, therefore, transferred to substances lower on the list. The triboelectric series order of ranking is not always constant nor repetitive. Also, the degree of separation of two substances does not necessarily

indicate the magnitude of the charges created by the triboelectric effect. The order of the series and magnitude of the charges are dependent upon the properties or nature of the substances. The properties of these substances are modified by surface cleanliness, ambient conditions, pressure of contact, speed of rubbing or separation, lubricity, and the amount of surface area over which the rubbing occurs. A sample triboelectric series is provided in Table 2-7.1. Note that the human body is high on the list. Substantial electrostatic charges can also be generated when two pieces of the same material are separated. An example of this would be when the sides of a plastic bag are separated.

2-7.4 Prime Sources of Static Electricity. Prime charge sources commonly encountered in manufacturing facilities are listed in Table 2-7.2. These prime sources are essentially insulators and are typically synthetic materials. Electrostatic voltage levels generated with these insulators can be extremely high since they are neither distributed over the entire surface of the substance nor conducted to another contacting substance. The conductivity of some resistive materials is increased due to the absorption of moisture during high humid conditions. This condition creates a slightly conductive moist layer which tends to dissipate static charges over the material's surface. Common plastics in a manufacturing facility can generate up to 15,000 volts of static electricity. Table 2-7.3 shows typical electrostatic voltages generated by personnel in a manufacturing facility.

2-7.5 Parts that are ESD Sensitive.

2-7.5.1 Numerous parts are susceptible to damage when an ESD occurs across their terminal or when the parts are exposed to electrostatic fields. These parts can be destroyed by an ESD when one pin is connected to a high voltage source and the other pins are not grounded. A hard ground connection is not necessary in order for an ESD sensitive part to be destroyed. With metal oxide semiconductor's large scale integrated devices contained in hermetic packages with nonconductive lids, damage could occur even if the part was not grounded by spraying the lid with canned coolant. When ESD sensitive parts are installed in assemblies where an ESD could cause damage, the leads are normally connected to enough conductive material to provide the proper grounding.

2-7.5.2 Assemblies and subassemblies are often as ESD sensitive as the most sensitive ESD sensitive part which they contain. Incorporation of protective circuitry in these assemblies and equipment can provide varying degrees of protection from an ESD. This equipment, however, is still vulnerable to an induced ESD caused by strong electrostatic fields and by contact with printed wiring board (PWB) electrical connections.

2-7.6 Types of ESD Failures.

2-7.6.1 Intermittent or upset failures, as well as hardware failures, can occur in electronics due to an ESD. Intermittent or upset failures can occur on certain types of parts such as large scale integrated memories and on chips before and after lidding and sealing. Such failures can also occur when equipment is in operation and are usually characterized by either a loss of information or a temporary distortion of its functions. With these types of failures, no apparent hardware damage occurs. After the ESD exposure, proper operation resumes either automatically or after reentry of the information which is done by resequencing the digital equipment.

2-7.6.2 Upset failures can be the result of an ESD spark in the vicinity of the equipment. The electromagnetic pulse generated by the spark causes erroneous signals to be picked up by the equipment circuitry. Upset failures can also occur because erroneous signals are induced by the capacitive or inductive coupling of an ESD pulse or by the direct discharge of an ESD through a signal path.

Table 2-7.1
Sample Triboelectric Series

Positive +	Air
	Human hands
	Asbestos
	Rabbit fur
	Glass
	Mica
	Human Hair
	Nylon
	Wool
	Fur
	Lead
	Silk
	Aluminum
	Paper
	Cotton
	Steel
	Wood
	Amber
	Sealing Wax
	Hard Rubber
	Nickel, Copper
	Brass, Silver
	Gold, Platinum
	Sulfur
	Acetate Rayon
	Polyester
	Celluloid
	Orlon
	Polyurethane
	Polyethylene
	Polypropylene
	PVC (Vinyl)
	KEL F
	Silicon
	Teflon
Negative	

Table 2-7.2
Typical Prime Charge Sources

Object or Process	Material or Activity
Work surfaces	<ul style="list-style-type: none"> • Waxed, painted or varnished surfaces • Common vinyl or plastics
Floors	<ul style="list-style-type: none"> • Sealed concrete • Waxed, finished wood • Common vinyl tile or sheeting
Clothes	<ul style="list-style-type: none"> • Common clean room smocks • Common synthetic personnel garments • Non-conductive shoes • Virgin cotton 1/
Chairs	<ul style="list-style-type: none"> • Finished wood • Vinyl • Fiberglass
Packaging and Handling	<ul style="list-style-type: none"> • Common plastic - bags, wraps, envelopes • Common bubble pack, foam • Common plastic trays, plastic tote boxes, vials, parts bins
Assembly, Cleaning, Test and Repair Areas	<ul style="list-style-type: none"> • Spray cleaners • Common plastic solder suckers • Solder irons with ungrounded tips • Solvent brushes (synthetic bristles) • Cleaning or drying by fluid or evaporation • Temperature chambers • Cryogenic sprays • Heat guns and blowers • Sand blasting • Electrostatic copiers

1/ Virgin cotton can be a static source at relative humidities below 30 percent.

Table 2-7.3 Typical Electrostatic Voltages

Means of Static Generation	Electrostatic Voltages	
	10 to 20 Percent Relative Humidity	65 to 90 Percent Relative Humidity
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes for work instructions	7,000	600
Common poly bag picked up from bench	20,000	1,200
Work chair padded with polyurethane foam	18,000	1,500

2-7.6.3 Upset failures occur only when the equipment is operating, but catastrophic failures can occur at any time. Catastrophic failures can be the result of electrical overstress of electronic parts caused by a discharge from a person or object, an electrostatic field, or a high voltage spark. Some catastrophic failures may not occur until some time after exposure to an ESD as in the case of failures resulting from marginally damaged ESD sensitive parts. These parts may require additional operating stress and further degradation in order for a catastrophic failure to occur. Only certain part types seem to be susceptible to this latent failure process. There are some types of catastrophic failures which could be mistaken for upset failures. For example, an ESD could result in aluminum shorting through a dielectric layer. Subsequent high currents flowing through the short, however, could vaporize the aluminum and open the short. This failure may be confused with upset failure if it occurs during equipment operation, but the damage due to the ESD would be a latent defect and would likely reduce the operating life of the part.

2-7.6.4 Parts that are very susceptible to ESD upset failures are logic families that require small energies or small changes of voltage in high impedance lines in order to switch states. Examples of these families are negative metal oxide semiconductors, positive metal oxide semiconductors, complimentary metal oxide semiconductors, and low power transistor-transistor logic. Linear circuits with high impedance and high gain inputs would also be highly susceptible along with radio frequency amplifiers and other radio frequency parts at the equipment level.

Design for radio frequency interference immunity can go a long way in protecting these parts from damage due to a high voltage ESD.

2-7.7 The DOD-HDBK-263 is an excellent source for more detailed information on ESD sensitive devices and control.

2-7.8 The requirement for ESD protection and control in development, production, and engineering services contracts is the responsibility of the QE Division of PAD and is imposed in contracts per MIL-STD-1686.

2-8 SOFTWARE QUALITY ASSURANCE (SQA)

2-8.1 The QE Division of PAD is responsible for the design, development, documentation, fabrication, validation, and control of all software incorporated in SIE. Section 2-10 of this pamphlet describes SIE in detail.

2-8.2 The systematic process of documentation review, test, and analysis to assure that the software product will satisfactorily serve its intended purpose is SQA. A properly conducted SQA effort provides the Government visibility into the quality of the development processes. It is the intent of SQA to build quality into the software by assuring that the software development process is conducted IAW all contractual requirements and good software engineering practices.

2-8.3 The software quality program requirements are set forth in DOD-STD-2168 which interprets the applicable requirements of MIL-Q-9858 as they apply to software. The software quality program requirements are to be applied during the development, acquisition, and support of software systems. This program's objective is to assure the quality of:

- a. deliverable software and its documentation.
- b. the process used to produce deliverable software.
- c. the software element of firmware.
- d. nondeliverable software used in the automated manufacture of deliverable hardware.
- e. nondeliverable software used in the qualification or acceptance of deliverable software or hardware.

2-8.4 The program includes planning for and evaluating software documentation and the timely resolution of problems. Formal qualification testing is covered in DOD-STD-2167. This document uses qualification testing as a means of verifying an item's performance to a specific application which is essentially development testing.

2-9 INSPECTION REQUIREMENTS

2-9.1 Definitions.

2-9.1.1 The definitions of the terms inspection, examination, and testing as stated in Federal Acquisition Regulation (FAR) clause 46.101 and MIL-STD-109, are summarized below:

a. Inspection. The examination and testing of supplies and services to determine whether or not they conform to specified requirements.

b. Examination. An element of inspection consisting of investigation to determine conformance to those specified requirements which can be determined without the use of special laboratory equipment or procedures. It includes the use of the senses (sight, hearing, smell, taste, and touch) as well as simple physical manipulation, gaging, and measurement.

c. Testing. An element of inspection that denotes the determination of conformance of supplies to stated requirements by technical means involving application of established scientific principles and procedures, including functional operation.

2-9.1.2 Some elements of both industry and Government mistakenly use the term "inspection" to denote examination and exclude testing. Some use the term "testing" to denote inspection and examination. This disparity of terms within the defense community leads to confusion. This pamphlet will standardize these terms and "inspection", "examination", and "testing" will be used as defined above.

2-9.2 Types of Inspection. There are many types of inspections conducted by the Army, defense contractors, and delegated Government inspection agencies. There are screening inspections (100%) and sampling inspections. There are design, development, operational, reliability, preproduction, and production tests. There are also qualification, first article (preproduction, initial production, pilot lot), quality verification, comparison, quality conformance, and periodic conformance inspections. The inspections addressed in this pamphlet will be limited to those inspections that are basically the responsibility of the QE Division, PAD, and are as follows:

a. Qualification Test. The testing of a product obtained from manufacturers or distributors for the purpose of determining conformance to specification requirements. If the product is in conformance, it is placed on a qualified products list. Qualification testing is generally performed in advance and independent of any specific acquisition action. This definition is essentially that of FAR clause 9.202(a), MIL-STD-109, and MIL-STD-961. It should be noted that MIL-STD-490 defines qualification as verification of item performance to a specific application. The MIL-STD-490 definition provides a basis for design approval of items covered by product function specifications at levels lower than that proven out by development/operational tests.

b. First Article Test (FAT). The FAT is the comprehensive inspection of a product before or during the initial stages of production. The purpose of this test is to insure that the contractor is capable of producing the product to the TDP and other specified requirements, using the facility, processes, and personnel intended to be used in production. One or more items may be required for inspection. The Government must include the FAR clause and alternate in the contract that requires the contractor to produce the first article at the same facility the production units will be produced. The Government also may authorize the contractor to procure materials and commence production prior to the completion of the FAT. The FAR clause chosen will also determine whether testing will be performed by the contractor or by the Government. The FAT normally includes environmental testing and, as stated in FAR clause 9.301, encompasses those various samples known as preproduction models, initial production samples, test samples, first lots, pilot lots, and pilot models.

c. Quality Verification Inspection (QVI). The QVI is performed by the Government to determine conformance of the product to specified requirements. It is a nondestructive test and is most often applied to low dollar value items with limited complexity. When FAT is specified for spare/repair parts and the dollar value is determined to be within the small purchase limitation as defined by FAR clause 13.000, the procurement policy is to change, with PAD's concurrence, the FAT requirement to a QVI and deliver the entire contract quantity to the Government for inspection and possible acceptance. A QVI may also be specified in major item procurements and involve the delivery of samples rather than the entire quantity. The requirements for the QVI are specified in the contract but not in the TDP.

d. Quality Conformance Inspection (QCI). The QCIs are those "normal" inspections prescribed in the TDP that are conducted during the course of production on every item or lot to determine the items conformance to specified requirements. A QCI is normally prescribed in the TDP for the contractor to perform but is subject to being witnessed or performed by the Government.

e. Periodic Conformance Inspection (PCI). The PCI is a comprehensive periodic inspection of a product during production and is performed after the product has passed the QCI. The requirements for this inspection are specified in the TDP and normally involve environmental testing. These inspections approach the FAT in severity and complexity and are intended to detect design, manufacturing, or quality deficiencies that may have developed during volume production. The PCI is sometimes referred to as a periodic environmental test (PET), a periodic environmental conformance test (PECT), or a periodic reliability verification test (PRVT).

f. Quality Assurance Lot Verification Test (QALVT). This test is the final QA test performed prior to lot acceptance (signing of the DD Form 250). A small statistical sample is selected at random from the lot for testing. The test units are subjected to launch and flight environments and are tested to their intended function. The test also verifies final integration and assembly of the completed units. The QALVT for missiles was formerly known as a "Fly-to-Buy" test. The requirements for the QALVT are normally specified in the contract SOW rather than in the TDP.

2-10 INSPECTION EQUIPMENT (IE) DEVELOPMENT, VALIDATION, AND CONTROL

2-10.1 Introduction

2-10.1.1 PAD has overall responsibility for the IE utilized in support of MICOM assigned weapon systems. This includes the definition, selection, policy, design, documentation, acquisition, fabrication, calibration, validation, operation, control, and disposition of SIE. This section of the pamphlet will address the methods and procedures utilized in accomplishing this mission. It will also address the methods and procedures used in imposing controls on other equipment utilized in inspecting the product.

2-10.1.2 Virtually all of industry and some elements of the Government refer to the term "test equipment" to denote the equipment used for inspection. Inspection includes the examinations and tests conducted on a product to determine its conformance to specified requirements. This definition is IAW with the definition of "inspection" as stated in MIL-STD-109, FAR clause 46.101 and section 2-9.1 of this pamphlet. PAD's definition of IE is, "equipment used for the examination, evaluation, and test of a product to determine its conformance to the requirements of applicable drawings, specifications, and other requirements documents". This definition includes dimensional gages, measurement equipment, electronic and physical test equipment, test fixtures, and other test equipment used for examination or test purposes.

2-10.2 Control of IE

2-10.2.1 The IE must be acquired, maintained, and dispositioned IAW MIL-I-45607 and calibrated IAW MIL-STD-45662.

2-10.2.2 A system must be implemented to prevent the unauthorized tampering of IE. Tamper-proof sealing must be accomplished by utilizing either wire/lead seals, pressure sensitive seals, decals, or labels, as appropriate. The breaking of tamper-proof seals and the recording of that event must be limited to contractor quality and Government inspection personnel. A break and entry log shall be required for each IE unit or station for use in the recording of each entry, activity, and resealing of that particular IE. Where an IE unit is portable and is moved from place to place, the log may be kept in the maintenance/calibration laboratory. Where the IE is fixed in place, such as an automated test station, the log shall be kept at that location. Once the IE has been established on the production line, any event, to include entry, that might cause the IE to be suspect is considered to be cause for calibration of the IE prior to its use in inspecting hardware.

2-10.3 Types of IE. There are three types of IE recognized by PAD that are used to verify conformance to specified requirements. These types are referenced in MICOM Policy 702-3, FAR

clauses 45.101 and 52.245-18 and are summarized below:

a. Commercial Inspection Equipment (CIE). Standard commercially designed equipment used to determine compliance to TDP requirements, with no modifications, having universal application without limitations to a specific commodity, item, or component. This equipment must be advertised or cataloged as being available to the trade or to the public on an unrestricted basis. If the CIE is modified or integrated with other test equipment to perform an inspection other than what it was designed for, it becomes either special inspection equipment (SIE) or special test equipment (STE).

b. Special Inspection Equipment (SIE). Equipment of a special design and configuration required to verify that the weapon system meets its contractual requirements. The SIE is that equipment used for Government acceptance criteria and requires Government validation/control. The SIE is used when the required production rates and/or accuracies cannot be supported using CIE or when the CIE cannot be economically obtained.

c. Special Test Equipment (STE). The definition of STE in FAR clauses 45.101 and 52.245-18 is summarized as equipment that is engineered, designed, fabricated, or modified to accomplish special purpose testing.

2-10.4 MICOM Policy on IE.

2-10.4.1 The IE used to verify compliance with the requirements of drawings, specifications, contracts, and other requirements documents is of primary concern to PAD. This IE will be classified as either CIE or SIE. Both CIE and STE used by the contractor in upstream inprocess inspections, but not for Government acceptance, is not normally under Government control.

2-10.4.2 Maximum utilization will be made of CIE for MICOM procured items. The development and utilization of SIE shall occur only when either CIE is not adequate for use in performing the required inspections or it is economically advantageous to the Government.

2-10.4.3 Consideration must be made as early as possible in all weapon system life cycle programs regarding the impact of using CIE versus SIE. In specifying the inspection methods required to support the QAPs, the contractor shall, as required, specify inspection methods utilizing either CIE or SIE. When inspection methods using SIE are specified, they will be at the highest level of inspection possible, consistent with contractual requirements.

2-10.4.4 All SIE proposals must include a design concept which must be approved by PAD prior to further consideration. The documentation must include detailed equipment descriptions (EDs), equipment operating instructions (EOIs), related software documentation, drawings, and associated lists. If the equipment requires calibration, the documentation must include detailed calibration procedures (CPs). All documentation is subject to approval by PAD. The CIE documentation will not be under Government control. However, both SIE and CIE require approval and validation by the Government if it is to be used as part of the acceptance criteria.

2-10.5 Special Inspection Equipment (SIE). Normally SIE is used in a relatively protected environment in a plant or depot and experiences little shock, vibration, or temperature extremes. These benign conditions allow for less stringent design and fabrication requirements relative to those of tactical items. Requirements are oriented more toward obtaining the required accuracy and repeatability, with acceptable reliability, in a cost effective manner. The term "SIE", as used herein, includes software, where software is required or exists, as well as hardware. The MICOM requirements for SIE are described in the following paragraphs.

2-10.5.1 Design of SIE.

2-10.5.1.1 A design concept for each SIE unit or test station must be submitted to the Government for approval. The proposed concept must include justification (need), cost, equipment options and their costs, physical and functional descriptions, sketches, block diagrams, and requirements for external calibration equipment. The justification must show that adequate CIE is not available or that an economic advantage to the Government will result. The equipment options will address the use of CIE, its cost, and the schedule impact.

2-10.5.1.2 Any further effort regarding the SIE unit or test station is not allowed prior to approval of the design concept. Where a change to the product is required for compatibility with the proposed SIE, the description and impact of the change must be included in the design concept.

2-10.5.1.3 Prior to approval of the design concept, an investigation must be conducted to determine if there are existing SIE designs that will, with or without modification, perform the intended function and the use of it will be in the best interest of the Government. When this is determined to be true, the Government will furnish the TDP for that SIE to the contractor.

2-10.5.1.4 For each inspection performed utilizing SIE, an alternate inspection procedure utilizing CIE must be developed and incorporated into the TDP, where possible. The alternate procedures must be validated and, based on their successful demonstration, approved by PAD. The alternate inspection procedures are procured for the purpose of competitive break out.

2-10.5.1.5 The design of SIE is required by MICOM to be, where practical, IAW the following criteria:

- a. Of minimum complexity to perform its intended function. Ease of maintenance, calibration, and operation must be major considerations.
- b. Operating controls, interfaces, and test points mounted externally.
- c. Calibration controls mounted internally to prevent inadvertent movement.
- d. Minimum use of switch paneling.
- e. Quick connect/disconnect interfaces.
- f. Control of the tolerances to assure that the equipment will provide the required accuracy readout so that good units will be accepted and bad units will be rejected.
- g. Utilize electrical and electronic components IAW best commercial practices. Parts availability to minimize maintenance downtime should be a major consideration.
- h. Use MIL-HDBK-204 as a guide for the design of gages but not for the preparation of documentation. For electronic or electrical test equipment not covered by MIL-HDBK-204, designs must conform to the best commercial practices. The equipment shall also utilize precision component parts and assemblies including temperature stabilization and electrical lead shielding features as applicable.
- i. Existing Government designs to be used including SIE and integrated family test equipment (IFTE).
- j. Maximum use of off-the-shelf commercial items as components of the SIE design including counters, timers, meters, power supplies, and gages.
- k. Software required for the SIE to be designed and developed IAW the software quality program plan specified for the tactical system software. If no software is required for the tactical hardware, the contractor shall establish and implement a SQA program for the SIE software IAW section 4 of DOD-STD-2167, DOD-STD-2168, and as specified herein. The high order language for newly developed SIE software shall be IAW ANSI-STD-716-1985. Format and style shall be IAW the IFTE test program set style guide.

2-10.5.2 Documentation of SIE. PAD requires that SIE be documented IAW MIL-T-31000 except where special conditions warrant otherwise. The SIE TDP consists of the following:

a. Drawings and associated lists. The drawings define the as-built configuration of the SIE. Parts and equipment lists may be on the drawing or on a referenced sheet.

b. Equipment descriptions (EDs). The EDs describe the purpose, maintenance, and function of the SIE. Where software is involved, the software requirements are described and defined. This documentation is identified by the SIE top drawing number preceded by the letters "ED". Note: If software is required, a print-out of the software program must also be required. The print-out is for the purpose of reviewing the software prior to validation.

c. Calibration procedures (CPs). Where calibration is required, detailed procedures for properly calibrating the SIE shall be defined. The CPs are identified by the SIE top drawing number preceded by the letters "CP".

d. Equipment operating instructions (EOIs). Detailed instructions for the proper operation of the SIE shall be defined. These instructions are identified by the SIE top drawing number preceded by the letters "OI".

2-10.5.3 Fabrication of SIE As a minimum, SIE fabrication requirements are to be IAW the best commercial practices. The soldering, workmanship, and internal wiring requirements are to be IAW MIL-STD-454, requirements 5, 9, and 69 respectively.

2-10.5.4 Validation of SIE

2-10.5.4.1 Before SIE is approved for use in inspecting and accepting production hardware, PAD requires Government validation of each SIE unit/test station. The validation procedure must demonstrate that the SIE meets all of its specified requirements and performs its intended function. It must also demonstrate that the SIE drawings define the as-built configuration of the SIE and, where applicable, that the software, EDs, CPs, and EOIs define the SIE and its intended functions. The CPs must include a verification method to assure that the SIE units are in calibration. The level of validation may vary depending on the nature of the SIE. It may be a simple gage or measurement device defined by one SIE drawing to measure a single requirement specified on the product drawing. Conversely, it may be a highly complex, automated, computer driven, electronic test station defined by numerous drawings, EDs, CPs, and EOIs, and capable of measuring a number of requirements specified in the product TDP. At any level, the validation must achieve the same purpose, which is to verify that the SIE is adequately defined by its TDP and that it is capable of performing its intended function.

2-10.5.4.2 At least 90 days prior to the scheduled validation, the contractor shall submit the software requirements and printout, the proposed EOI, and the validation procedure plan for PAD approval. The validation plan shall include a section defining the software validation IAW ANSI STD 1012-1986. Following approval of the requirements, EOI, and validation plan, the contractor shall conduct a preliminary validation and, at least 10 working days in advance of the scheduled validation, notify the MICOM contracting officer that the validation procedure has been successfully conducted, and that the SIE will be ready for Government validation on the scheduled date. At least 72 hours prior to the scheduled validation, the contractor shall confirm through the contracting officer that the validation will be conducted as scheduled. In the event the validation cannot be successfully accomplished as scheduled, the validation will be rescheduled and repeated until it is successfully completed. No SIE unit nor test station may be used for the inspection of product until it has been successfully validated and attested to by a validation certificate signed by both the contractor and the Government.

2-10.5.4.3 The validation procedure consists of three major functions as follows:

2-10.5.4.3.1 A TDP review. The purpose of the TDP review is to verify that the SIE is capable of performing the function for which it was designed. This is accomplished by combining a table top review with the demonstration. The table top review must compare the SIE drawings and EOIs with the product drawings and specifications. This will assure that an adequate

procedure is defined in the SIE documentation that will verify that all of the requirements specified in the product documentation are covered. The demonstration will then show that the SIE will, in fact, verify those requirements.

2-10.5.4.3.2 A Physical Configuration Audit (PCA). During the PCA, the SIE is compared to its documentation for the purpose of verifying that the documentation defines both the SIE hardware and software. The audit must be conducted in such a manner as to avoid damage to the SIE.

2-10.5.4.3.3 A functional demonstration. A SIE functional demonstration shall be conducted by qualified contractor personnel IAW all of the associated documentation and witnessed by a PAD representative. Prior to the demonstration, the equipment requiring calibration shall display evidence, in the form of calibration decals or stickers, that it is in calibration. The capability of the SIE to accurately measure parameters by accepting conforming product and rejecting nonconforming product at the parameter threshold shall be demonstrated. The interface compatibility with the product and the accuracy and completeness of the CPs and EOIs shall also be demonstrated. Normally the demonstration requires the inspection of at least three product units under test (UUTs). These UUTs must have been inspected by alternate inspection methods to assure that they conform to the TDP and to verify that the SIE will accept conforming hardware. The demonstration shall also consist of the inspection of a UUT with at least three different types of induced faults to verify that the SIE will reject nonconforming product based upon each of the faults. Six different type faults shall be planned and documented by the contractor. The PAD representative will select three of the planned faults for the demonstration. The three faults shall be induced in a manner that will not damage the UUT. A successful demonstration is one that proceeds smoothly from beginning to end IAW the CPs and the EOIs without omitting or repeating steps, obtaining incorrect results, SIE malfunctions, UUT malfunctions, interface problems, or any other interruptions. When such interruptions occur, corrective action must be taken and the demonstration repeated from the start. During the demonstration, every step in the procedure must be sequentially conducted. The demonstration is considered invalid if undocumented steps are conducted.

2-10.5.4.4 The following actions are required following a successful validation:

- a. Where appropriate, the SIE shall be sealed, and a break and enter logbook shall be attached to it with the calibration and validation dates recorded and attested to therein.
- b. A validation certificate attesting to the successful completion of the validation shall be signed by the appropriate contractor and PAD representatives. This shall include certificates for both SIE hardware and software.
- c. A report regarding each unit of SIE validated shall be prepared by the contractor and submitted to the Government. The report must include the data from the validation and an analysis of any variation to the repeatability capabilities of the equipment. The report must contain a statement by the contractor that the SIE performs to its required capability. Upon approval of the PAD representative, the SIE is ready to be used for the inspection of product.

2-10.5.5 Configuration Control of SIE. Upon validation and certification to the Government, all SIE documentation comes under the same configuration control (contractor and Government) as the product (weapon system) documentation (MIL-STD-480). All proposed changes must be processed through the applicable MICOM CCB.

2-10.5.5.1 The approval of all engineering change proposals (ECPs), including those for SIE, requires the concurrence of the applicable PAD CCB member.

2-10.5.5.2 In considering an ECP for an item where the inspection of it requires the use of SIE, the Government must evaluate the impact, if any, of the proposed product change on the SIE.

The contractor should address any SIE impact by either the product ECP or in a concurrent SIE ECP. If the proposed change impacts the SIE, and the impact is not addressed by ECP, the PAD CCB member must recommend either rework or disapproval of the ECP.

2-10.5.5.3 In reviewing an ECP regarding SIE hardware, software, or documentation, the QE must consider the magnitude, complexity, and impact of the change. Where the change is determined to be beneficial, the QE must determine if the change requires SIE revalidation. Where revalidation is considered necessary, the SIE must remain off line until it can be revalidated and recertified.

2-10.5.5.4 Unauthorized changes to SIE hardware, software, or documentation are not allowed. The utilization of SIE to redlined documentation, such as drawings, EDs, CPs, EOIs, computer data, and undocumented configurations is prohibited.

2-10.5.5.5 A proposed deviation to any approved SIE hardware, software, or documentation must be formally submitted by a RFD to the applicable MICOM CCB. Approval of the RFD requires concurrence by the PAD CCB member. The RFD may be approved within specified constraints, such as when the deviation is necessary and beneficial to the Government and when effective corrective action is planned in a satisfactory and timely manner. Deviations are discouraged but will be granted when in the best interest of the Government.

2-10.6 Integrated Family Test Equipment (IFTE)

2-10.6.1 The IFTE is computerized electronic core test equipment that is Government designed. It forms a total test facility when integrated with a test program set consisting of adapters, computer software, and interfaces designed for a specific application. The IFTE was originally known as intermediate forward test equipment.

2-10.6.2 There are two versions of IFTE. One is a militarized version, AN/TSM-191 (V2), called a base shop test facility, and the other is a commercial version, AN/GSM-340 (V), called a commercial equipment equivalent. The base shop test facility is designed to go with the field Army and to withstand severe environments and rough handling and is built with high reliability parts, materials, processes and controls. The commercial equipment equivalent is designed for use in Army depots and contractor plants (where it is in a fixed position and protected environment) and is designed and fabricated to less stringent requirements.

2-10.6.3 Both versions are designed as standard test equipment capable of being used with most Army weapon systems and field support equipment when interfaced with the proper test program sets.

2-10.6.4 The Department of the Army's (DA's) purpose in developing IFTE is to reduce costs associated with the design and fabrication of SIE and field Army system peculiar test equipment. A policy letter to this effect was issued by the Executive Director for U.S. Army Test, Measurement, and Diagnostic Equipment Support Group and addressed to the Commanding General, MICOM, and others. PAD now requires development contractors to perform an economic analysis of the impact of using IFTE in lieu of other IE.

2-10.7 Depot IE. The QE Division of PAD is responsible for the validation of each depot IE unit or test station. The validation consists of the same functions and requirements as does the contractor SIE validation.

2-11 QUALITY ENGINEERING PLANNING LIST (QEPL)

2-11.1 The QEPL is a complete list of documents that specify QAPs (existing and planned) and all associated SIE required in the performance of Government imposed inspections. The documents include drawings, specifications, DMWRs, and SSSs. Each major assembly is identified on a separate sublisting, and all of its subsystems, items, and components are listed in generation breakdown order. The separate sublists are then combined to form the complete QEPL.

2-11.2 The QEPL may be formatted on DARCOM Form 2485-R (Modified) or on a Government approved contractor form that contains, as a minimum, the information specified on the DARCOM form. An example of a QEPL sublist is provided in Figure 2-12.1.

2-11.2.1 In reference to Figure 2-12.1, blocks 1 and 2 identify the major assembly by nomenclature and part number, respectively. Block 3 identifies the item manager; block 4, the approval date of the listing; block 5, the developer that submitted the listing; block 6, the name and signature of the approval authority; and blocks 7 and 8, the page number and number of pages of the listing. Block 9 identifies the subassemblies in the generation breakdown by denoting them with the letter "A" in the column. Blocks 10 and 11 list the part numbers and nomenclature of the major assemblies and the generation breakdown. Block 12 identifies spare/repair parts by denoting them with the letter "X" in the column. The documents that specify QAPs and the associated SIE, both in existence and planned, are listed in block 13. Where the required document or SIE is already in existence, it is listed by document number or part number respectively. Where there is no requirement for QAPs nor SIE, it is acknowledged by the notation "NR".

2-11.2.2 When referring to the Transmission Assembly, P/N 872XXXX, at the top of the listing in Figure 2-12.1, note the following:

- a. In Block 12, an absence of the letter "X" denotes that it is not a repair part.
- b. In the Spec column of Block 13, MIL-T-XXXXXX denotes that QAPs are denoted in an existing specification.
- c. In the DWG column of Block 13, QAPs are not required as denoted by the letters "NR".
- d. In the DMWR and SSS columns of Block 13, QAPs are required but have not been generated as denoted by the letter "R".
- e. In the SIE column of Block 13, the required SIE has been fabricated and documented as denoted by the SIE part number.
- f. Block 14 provides special information such as the reason that QAPs were not prepared for the items so identified in block 13.

2-11.2.3 Referring to the next item, Housing Assembly, P/N 869 XXXX, it is noted that:

- a. It is an assembly.
- b. It is a spare/repair part.
- c. It requires no specification.
- d. There is an existing drawing containing QAPs.
- e. QAPs are required in the DMWR and SSS but are yet to be generated.
- f. SIE is required but is yet to be validated.

2-11.3 The QEPL identifies the QAPs and the SIE documentation (existing and planned) for mature items, for newly developed items, and for items undergoing design changes, at any given point in the development cycle. The QEPL is initiated early in the life cycle, continuously updated, and is finalized at the end of the development stage as a list of all QAPs, SIE, and related documentation. It is used to show the status of QE documentation, to plan work, and to cross-index the QE documentation with the design engineering documentation. In the early phases of a development program, the QEPL identifies areas where QE documentation is available and also

Quality Engineering Planning List (QEPL) DARCOM P-702-2				3. Installation: UNITED STATES ARMY TANK-AUTOMOTIVE RESEARCH AND DEVELOPMENT COMMAND				4. Date 27 Aug. 1986			
1. Nomenclature Transmission Assembly		2. QEPL Number: 872XXXX		5. Submitted By: XYZ Corporation		6. Approved By: H. Smith		7. Page: 1		8. No. of: 8	
9. Assy.	10. Part Number: 872XXXX	11. Nomenclature Transmission Assy	12. Repair Part	Spec	DWG	DMWR	SSS	13. Quality Assurance Documentation		14. Other Information	
A	869XXXX	Housing Assy	X	MIL-T-XXXXX	NR	R	R	R	R	Spec Contains Adequate mfg. QAP's	
	835XXXX	Housing Cover	X		869XXXX	NR	NR	NR	NR		
	832XXXX	Gasket	X		835XXXX	NR	NR	NR	NR	Simple Item Cork/rubber	
	838XXXX	Retainer Plate	X		R	NR	NR	NR	NR		
	775XXXX	Spacer	X		R	NR	NR	NR	NR	Simple Item	
	776XXXX	Pump Assy	X		R	NR	NR	NR	NR	Simple Item Commercial Item	
A	872XXXX	Shaft	X		R	NR	NR	R	R		
	876XXXX	Bearing	X		R	NR	NR	R	R	Commercial Item	
	867XXXX	Housing	X		862XXXX	R	NR	R	R		
	865XXXX	Seal Ring	X		R	NR	R	NR	NR	Commercial Item	
	862XXXX				862XXXX	R	NR	R	R	Commercial Item	
	860XXXX				R	NR	R	NR	NR	Commercial Item	
A	872XXXX	Shaft Assy	X		872XXXX	R	NR	R	R		
	870XXXX	Shaft	X		R	NR	R	NR	R		
	867XXXX	Gear	X		R	NR	R	NR	R		
	832XXXX	Bearing	X		R	NR	R	NR	R		
	831XXXX	Snap Ring	X		R	NR	NR	NR	NR	Commercial Item	
	852XXXX	Bracket	X		R	NR	NR	NR	NR	Commercial Item	
	861XXX	Cap	X		R	NR	NR	NR	NR	Simple Item	

(Previous Edition is Obsolete)

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Figure 2-12.1 QEPL Example

areas where it must be prepared. The QEPL is traceable to the current configuration of each item and can, therefore, be utilized as a current reference list of all applicable QAPs, SIE, and related documentation for the items. It is compiled from the engineering drawings list and the generation breakdown list and shows the relationship of parts, subassemblies, assemblies, and installations. Final approval of the QEPL is the responsibility of the QE Division, PAD.

2-12 TRAINING/CERTIFICATION

2-12.1 Specialized training is required in a number of areas under the product assurance umbrella for the purpose of qualifying technicians or operators to perform given tasks. In some cases, certification is required as written evidence of that qualification.

2-12.1.1 The training/certification requirements for a particular area are specified in the applicable Military/DOD standards, specifications, or pamphlets or may be written into the SOW. Operators and inspectors for soldering, welding, magnetic particle, liquid penetrant, eddy current radiographic, and ultrasonic functions require training/certification IAW their respective requirements.

2-12.1.2 Training/certification requirements will be written into the SOW for other areas as desired. For instance, the QE Division, PAD must determine if there is a need to establish a requirement in the SOW for training for SPC, ESS, component rescreening, or ESD. Consideration must also be given to other needs for training/certification. For instance, a weapon system consisting of parts to be joined together by adhesives (especially if "state of the art" materials are to be used) could benefit from a training/certification program regarding the specific materials and applications that are specified. The QE Division must make the decision as to what should be included in the SOW.

CHAPTER 3

QUALITY ASSURANCE PROVISIONS (QAPS)

3-1 INTRODUCTION

3-1.1 QAPs are the documented methods and procedures designed, implemented, and maintained to assure that supplies and services conform to all stated requirements. QAPs establish the procedures to be conducted to verify that contractually specified technical requirements and product assurance standards are complied with. They specify the implementation and proper conduct of all elements of the quality program, starting from the beginning and continuing throughout the life of the system. QAPs are developed for the system specification during the Concept Exploration and Definition phase. During the Demonstration and Validation phase, QAPs are established for the development specifications. During the Engineering and Manufacturing Development phase, QAPs are developed and validated for the product specification, fabrication specification, and drawings. The QAPs are then specified in the Production and Deployment phase and continue to be specified in follow-on production contracts, spare/repair parts contracts, and engineering services contracts. They carry over into the Operations and Support phase as specified in depot and field maintenance documents. This chapter provides information and guidelines to be used in specifying QAPs for use in the concept, development, procurement, and maintenance of MICOM assigned weapon systems.

3-1.2 QAPs are specified in three broad areas of documentation: the contract, the Government TDP, and the appropriate depot and field maintenance documents. These are defined as follows:

a. The Contract. QAPs, as part of the QE requirements, are originally specified in the Request for Proposal (RFP) or Invitation for Bid (IFB) and then transferred into the contract as negotiated. The QE requirements normally appear in the following areas of the contract:

(1) The Statement of Work (SOW) in section H (Special Contract Requirements) of the contract or as an attachment. The SOW is a descriptive narrative of the requirements.

(2) The Document Summary List (DSL) as an attachment to the contract. It is a list of documents, to include tailoring and category, imposed by the contract.

(3) The Contract Data Requirements List (CDRL - DD Form 1423) as an attachment to the contract. The CDRL is a list of Data Item Descriptions (DIDs) that provide the types, quantities, and delivery requirements of data required by the contract.

(4) The list of FAR clauses in section I (Contract Clauses) of the contract. In some cases, the clause itself must be inserted in the contract with the required data specified therein.

(5) The inspection and acceptance requirements in section E (Inspection and Acceptance) of the contract. Section E defines where the product line items will be inspected and accepted and the inspection requirements they must meet.

(6) Other instructions, conditions, and notices to offerors or quoters are contained in section L (Instructions, Conditions, and Notices to Offerors) of the contract.

(7) Factors for evaluating the contractors proposals/bids are prescribed in section M (Evaluation Factors for Award).

b. The Government TDP. The TDP is the technical documentation that defines a product and any related SIE. Upon acceptance by the Government, the TDP is placed under Government configuration control. A MICOM TDP normally consists of military specifications and standards, missile specifications (MISs), and technical drawings and associated lists (parts and equipment lists). QAPs incorporated in specifications and on drawings are procedural type requirements such as inspection procedures, levels of inspection, sampling plans, acceptance criteria, and any other requirement necessary to verify compliance with specified requirements. Although verification procedures are normally contained in the TDP, those that vary from contract to contract, such as QALVTs, are defined in the SOW.

c. Depot and Field Maintenance Documents. These documents are for field support of a specific product in the overhaul, maintenance, and storage areas and include DMWRs and SSSs.

3-2 QAPS IN CONTRACTS

3-2.1 Level of Quality Requirements.

3-2.1.1 The level of quality requirements is set by; (1) selecting the category of the program requirements IAW FAR subpart 46.2; (2) selecting the appropriate QE requirements as detailed in Chapter 2 of this pamphlet; and (3) specifying the category of cited documents and tailoring the documents in the DSL to the specific procurement.

3-2.1.2 The level of quality requirements to be specified is determined by the technical description, the complexity, and the criticality of the item being procured. FAR subpart 46.2 provides the guidelines to be used in determining the proper level to be specified. However, the final determination is the responsibility of the QE Division, PAD. The four levels in ascending order of severity are:

a. FAR clause 52.246-1. To be used where it is determined that there is no need for Government inspection prior to acceptance, and the procurement is within the small purchase limitation as defined in FAR part 13.000. The point of acceptance is also specified in the correspondence to the requiring activity. Normally there are no documents cited nor data required for this level of quality requirement.

b. FAR clauses 52.246-2 through 52.246-10. To be used where it is determined that the contractor must provide and maintain an inspection system that is not required to be IAW MIL-I-45208 but must be acceptable to the Government. The particular clause to be used depends on the type of contract that is specified. The appropriate clause as well as the points of inspection and acceptance are provided to the requiring activity. Normally there are no documents cited nor data required for this level of quality requirement.

c. FAR clause 52.246-11. To be used where it is determined that the contractor must provide and maintain either an inspection system IAW MIL-I-45208 or a quality program IAW MIL-Q-9858. The two documents are never to be imposed in the same contract but are to be used when conditions are as follows:

(1) MIL-I-45208 is to be imposed when the contract is for items that are either complex or critical or both, but where it is determined that a comprehensive quality program is not required. MIL-I-45208 must be specified in FAR clause 52.246-11, in the SOW, and, along with the appropriate revision and category, in the DSL. If tailoring of the document is necessary for a specific procurement, it is added to the DSL. Where a DID is specified in the CDRL, it must be assigned a category, tailored, if necessary, and included on the DSL.

(2) MIL-Q-9858 is to be imposed when the contract is for items that are both complex and critical, and where it is determined that a Government-specified comprehensive quality program is required. MIL-Q-9858 must be specified in FAR clause 52.246-11. MIL-Q-9858 and the appropriate supplementary requirements, as detailed in Chapter 2 of this pamphlet, will be specified in the SOW. MIL-Q-9858 and the other documents cited in the SOW must then be tailored to the specific procurement and included in the DSL along with the appropriate revision and category. When a DID is specified in the CDRL, it must be assigned a category, tailored, if necessary, and included in the DSL.

3-2.1.3 When either MIL-I-45208 or MIL-Q-9858 is invoked in a contract, the appropriate standard inspection clause, selected IAW paragraph 3-2.1.2(b) above, must also be specified. This is necessary since neither MIL-I-45208 nor MIL-Q-9858 contains inspection requirements.

3-2.1.4 In addition to the appropriate FAR clauses above, FAR clause 52.246-16 must be specified in contracts and solicitations involving supplies.

3-2.1.5 Any document cited in a SOW, including a DID, must be listed in the DSL. The document revision, the category, and the tailoring that makes it compatible with the specific procurement, must be specified. The categories specify the depth of applicability and effectiveness and are as follows:

- a. Category 0 (Cat. 0). The requirements contained in the directly cited document are not mandatory but are for guidance and information only.
- b. Category 1 (Cat. 1). The requirements contained in the directly cited document are contractually applicable to the extent specified. The requirements contained in referenced and subsequently referenced documents are contractually for guidance and information only, unless otherwise specified in the solicitation, contract, or contract modifications.
- c. Category 2 (Cat. 2). The requirements contained in the directly cited document and the referenced documents in the directly cited document are contractually applicable to the extent specified. The requirements contained in the subsequently referenced documents of the referenced documents are contractually for guidance and information only, unless otherwise specified in the solicitation, contract, or contract modifications.
- d. Category 3 (Cat. 3). The requirements contained in the directly cited document and all referenced and subsequently referenced documents are contractually applicable to the extent specified, unless otherwise stated in the solicitation, contract, or contract modifications.

3-2.2 Quality Requirements Relationship to the Life Cycle Phase. The type and level of quality requirements specified in contracts are dependent on which phase of the life cycle the system is in. As stated in Chapter 2 of this pamphlet, limited requirements are first imposed in the Concept Exploration and Definition phase. As the system develops through the life cycle, the quality requirements are expanded and become more stringent. This trend is also applicable to QAPs specified in the TDP. QAPs will not be addressed in this section, but the contractual requirements that define and control the QAPs will be.

3-2.3 Specifying the Requirements. All of the quality requirements specified in the standard SOW may not be applicable to the SOW that goes into a specific RFP/IFB/contract and, therefore, must be tailored for each procurement. This pamphlet does not replace sound engineering judgement.

3-2.3.1 Concept Exploration and Definition Phase. This phase is primarily the planning phase. The contractor begins planning the programs and the methodology for implementing them. A limited quality program and a preliminary plan for a CSI program will be established. The system specification, which transposes user requirements to technical requirements at the system level, will be generated and will include the QAPs that are required to verify compliance. When released, the system specification forms the functional configuration baseline. The following quality requirements are normally imposed in the SOW:

a. Quality Program Requirements: The contractor will be required to develop and implement a quality program using MIL-Q-9858 as a guide. At this early stage, the program is expected to be very limited. Most of the requirements specified in MIL-Q-9858 are not appropriate and will be tailored out in the DSL. A program plan DID is not required by the Government. MIL-Q-9858 will be imposed as a category 0 in the DSL. The processing of nonconforming material shall be IAW MIL-STD-480 which will be tailored in the DSL to delete all references to MIL-STD-1520. This tailoring disallows the repair of a major nonconformance and subsequent processing of the action (as a minor nonconformance) through the Material Review Board (MRB) without a MICOM approved repair procedure.

b. The CSI Program: The contractor will be required to initiate preliminary planning for the implementation of a CSI program using AMC-R 702-32 as a guide. As with MIL-Q-9858, most of the requirements of AMC-R 702-32 are not yet appropriate and no CSI program plan DID is required. However, the CSI program requirement exposes the contractor to future requirements and guides the planning for the desired program. AMC-R 702-32 will be listed in the DSL as category 0.

c. QAPs in Technical Data: The contractor will be required to incorporate QAPs in chapter four of the system specification. The system specification establishes the system's functional baseline and is the principal technical document required during this phase. Since detailed test procedures are yet to be developed, the QAPs are expected to be general and descriptive in nature. However, the method to be used for verifying each of the technical requirements should be specified.

3-2.3.2 Demonstration and Validation Phase. During this phase, the contractor begins organizing various programs. Long range planning is accomplished. Detailed design is in progress. Test plans are formulated, breadboard prototypes are developed, and tests and evaluations are virtually continuous. System requirements are allocated down to the assembly levels and are transposed to stand-alone assembly requirements. Development specifications are generated, and detailed QAPs are developed to verify the requirements. When released, these specifications form the system allocated baseline. During this phase, the contractor will be required to update and maintain the quality program, to develop and implement the CSI program, and to develop a preliminary QEPL. Initial planning will be performed for the necessary IE. The following requirements are normally imposed in the SOW:

a. Quality Program Requirements. As in the Concept Exploration and Definition phase, MIL-Q-9858 will be invoked in the contract and will be used by the contractor as a guide in establishing the quality program. A quality program plan (QPP), which details the quality program, is required and is subject to Government approval. Although upgraded and expanded, the quality program is again expected to be limited in nature. An appropriate DID is to be specified for guidance in developing the plan. MIL-Q-9858, this pamphlet, and the DID are tailored, as necessary, and listed in the DSL. Since data is required, a CDRL is generated for the data delivery requirements. The processing of nonconforming material shall again be IAW MIL-STD-480 which will be tailored in the DSL to delete all references to MIL-STD-1520. This tailoring disallows the repair of a major nonconformance and subsequent processing of the action (as a minor nonconformance) through the MRB without a MICOM approved repair procedure.

b. Critical Safety Item (CSI) Program. The contractor will be required to develop and implement a CSI program using the guidance presented in AMC-R 702-32. A CSI program plan, IAW the guidelines of an appropriate DID, will be required. The CSI program plan may be included as a section of the QPP. The CSI program and plan will be limited in scope during this phase of the life cycle. AMC-R 702-32 and the DID will be tailored, as necessary, and included in the DSL.

c. Quality Engineering Planning List (QEPL). The contractor will be required to develop and implement a preliminary QEPL using the guidelines presented in an appropriate DID. The QEPL is expected to be rudimentary during this phase. The DID will be included in the DSL, and the delivery requirements will be included in the CDRL.

d. QAPs in Technical Data. The contractor will be required to develop and incorporate QAPs in the development specifications IAW MIL-STD-490. The development specifications define the allocated technical requirements and are the principal technical documents required for this phase. Fairly detailed procedures for the verification of technical requirements are required, and test documents are cited. The cited documents are tailored to include only the requirements that are relative to development specifications and are included in the DSL as category 1. Since these documents are mandatory requirements, they must be approved by the QE Division, PAD. QAPs are incorporated in specifications and drawings which have their own delivery requirements. Therefore, separate delivery requirements for the QAPs are not required in the CDRL.

e. Inspection Equipment (IE). The contractor will be required to plan for the design of the IE (both CIE and SIE) that is required to verify technical requirements. SIE will be planned for only when necessary. No DID or CDRL is required.

3-2.3.3 Engineering and Manufacturing Development Phase. The QE function increases significantly in this phase. The design reaches maturity and is qualified and documented. Development and operational tests are completed. Vendors are qualified, and vendor control procedures are developed and implemented. The configuration management procedures are implemented, and the CCB is established. The product TDP is developed and then validated by successfully passing both the functional configuration audit (FCA) and the PCA. Near the end of this phase, the CCB activity may be intense as last minute changes are incorporated, and the TDP is refined. The TDP is then released to the Government, thereby establishing the product baseline. Production facilities and production lines are formulated, established, and qualified. Field documents are generated, maintenance and overhaul requirements are established, spare/repair parts are identified, and provisioning lists are established. The SIE and the depot test equipment are designed, fabricated, and validated. Procurement of long lead items is initiated, and many other activities are accomplished to achieve production readiness. Quality requirements are expanded for this phase. Previously imposed provisions are enhanced and restated, and new provisions are added. Cited documents are imposed mostly as category 1, 2, or 3, thus making them requirements rather than guidelines. When imposed as requirements, the documents, including cited DIDs, must be tailored to the specific procurement by the QE Division, PAD. Depending on the nature of the procurement, some combination of the following requirements are imposed in the SOW:

a. Quality Program Requirements. The contractor will be required to implement and maintain his quality program IAW MIL-Q-9858 and any of the quality requirements specified in the SOW. A QPP IAW the appropriate DID will be required. MIL-Q-9858 and the DID are tailored for this phase and are included in the DSL as category 2 and category 1, respectively. Data delivery requirements for the plan are included in the CDRL. The processing of nonconforming material shall be IAW MIL-STD-480 which will be tailored in the DSL to delete all references to MIL-STD-1520. This tailoring disallows the repair of a major nonconformance and subsequent processing of the action (as a minor nonconformance) through the MRB without a MICOM approved repair procedure.

b. Statistical Process Control (SPC). The contractor shall conceive, plan, implement, and maintain a SPC program IAW with the American Society for Quality Control (ASQC) documents B1, B2, and B3 (formally known as the American National Standards Institute (ANSI) standards Z1.1, Z1.2, and Z1.3) and the SOW requirements. A plan that details the SPC program shall be submitted, as a section in the QPP, to the Government for approval. The plan shall include a time phase implementation schedule and shall address policy/scope, management structure, inspection/test equipment calibration and control, and auditing and review procedures. The plan shall also address general SPC procedures to include criteria for using SPC; criteria for process capability studies, control chart policy, failure analysis/corrective action policy, and the use of computer hardware/software. The ASQC documents will be included in the DSL as category 1.

c. Critical Safety Item (CSI) Program. The contractor shall implement and maintain a Government approved CSI program IAW AMC-R 702-32 and the SOW requirements. For this phase, AMC-R 702-32 is tailored and included in the DSL as a category 2. The requirements stipulate that the contractor shall identify CSIs and critical safety processes and incorporate them into a CSI list. This list shall be maintained throughout the contract period to identify the critical characteristics of each item, to establish strict process controls, and to require 100% inspection of the items. The contractor shall validate that the critical safety aspects of the design are accurately reflected in the drawings and specifications. The CSIs, critical safety characteristics, and critical safety processes shall be documented IAW DOD-STD-100. The contractor shall establish an executive level office and manager responsible for the CSI program contractual requirements and implementation thereof. A CSI program's plan shall be required as a section of the QPP. A DID

will be included in the DSL for the CSI list as category 1. Data delivery requirements will be included in the CDRL.

d. Supplier Quality Control. The contractor shall establish, implement, and maintain a supplier QA program IAW MIL-STD-1535. The contractor will be required to qualify suppliers, generate and maintain an approved suppliers list, and evaluate the supplier's performance for their inclusion or removal from the list.

e. Environmental Stress Screening (ESS). The contractor shall establish and implement ESS requirements and procedures IAW Task 301 of MIL-STD-785 and the SOW requirements. The contractor shall develop ESS profiles for applicable items, conduct the screens and apply failure reporting, perform analyses, and take corrective action IAW Task 104 of MIL-STD-785 to prevent their reoccurrence. The contractor shall prepare the following; a procedures and implementation plan, a report describing the ESS for prototype qualification tests, proposed ESS requirements and procedures, screening results, status and progress of the program, and drawings for the required jigs, fixtures, and test circuitry. MIL-STD-785 and the appropriate DID for the required data are to be tailored and included in the DSL as category 2 and category 1, respectfully. Data delivery requirements are to be included in the CDRL.

f. Electrostatic Discharge (ESD) Sensitive Devices. The contractor shall handle, mark, and manufacture ESD sensitive devices IAW MIL-STD-1686 and annotate applicable drawings IAW DOD-STD-100. The contractor shall include his proposed methods and procedures in a plan prepared IAW the appropriate DID. MIL-STD-1686 and DOD-STD-100 are included in the DSL as category 2, and the DID is included as category 1. Data delivery requirements will be included in the CDRL.

g. Quality Engineering Planning List (QEPL). The contractor shall prepare and maintain a QEPL IAW the appropriate DID. The DID will be included in the DSL as category 1. Data delivery requirements for the QEPL will be included in the CDRL.

h. QAPs in Technical Data. The contractor shall incorporate QAPs into the TDP and field documents. Requirements for the inclusion of QAPs in specifications, drawings, DMWRs, and SSSs will be specified in the SOW. The appropriate specifications, standards, and DIDs will be included in the DSL as category 1. Since the QAPs are an integral part of the documentation and required to be delivered under another section of the contract, no additional delivery requirements are necessary.

i. Documentation Reviews. The contractor shall develop and implement a procedure that provides for the review and approval of all specifications, drawings, SIE documentation, and DMWRs by the QE element. Detailed requirements will be specified in the SOW, and referenced documents included in the DSL as category 0. No data is required.

j. Inspection Equipment (IE). The contractor shall acquire, maintain, and disposition all IE IAW MIL-I-45607. The contractor shall implement a system to prevent unauthorized personnel from tampering with IE and to require the documenting of any authorized entry of that equipment. Detailed requirements for the design, documentation, fabrication, validation, and configuration control of SIE will be specified in the SOW. The requirements for depot IE will be included. The cited document and the appropriate DID will be included in the DSL as category 2 and category 1, respectively. Data delivery requirements will be included in the CDRL.

k. Inspection Equipment (IE) Software. DOD-STD-2167 and DOD-STD-2168 will be imposed as requirements when it is anticipated that the IE will require software. This includes nondeliverable as well as deliverable software and the software element of firmware. If the contract/solicitation includes tactical software, the SOW will state that the requirements for tactical software shall apply to the IE, and that the IE software shall be addressed in the tactical software quality program. If tactical software is not addressed nor provided for, the above DOD standards will be included in the SOW and in the DSL as Category 2. The appropriate DID for the preparation of SIE software product specifications, including the test/self-test codes, will be included in the DSL as category 1. Data delivery requirements for the specifications will be included in the CDRL.

l. Training. The contractor shall determine the necessary indoctrination and training requirements and establish training programs and certification procedures for personnel whose

work either requires special skills or has a significant effect on product quality. The training plan and the procedures for compliance must be included in the QPP. There are no documents required to be referenced in the DSL nor additional data delivery requirements in the CDRL.

m. Quality Reports. The contractor shall prepare monthly quality assessment reports, to include production quality, SPC, CSI, ESS, QAP and SIE development, and ESD programs, for submittal to the QE Division of PAD. The reports shall address all aspects of the contractor's quality program and each requirement in the SOW. The reports shall delineate the status of each quality requirement and assess the status against the QPP. They shall address problem areas and define both the cause and the corrective action. The appropriate DID will be included in the DSL as category 0. Data delivery requirements will be included in the CDRL.

n. Quality Reviews. The contractor shall conduct product assurance reviews at the production facilities on a quarterly basis. The reviews shall address all aspects of the product assurance program and requirements. An update of the status of the programs and an assessment of their condition against the associated plans shall be periodically performed. The reviews shall update the status of the issues in the quality assessment reports for the period and delineate the progress made against each of them. The DID will specify the format for the agenda, material presentation, and minutes.

o. First Article Test (FAT). The contractor shall perform the FAT as specified in the first article clause (FAR clause 52.209-3) of the contract. If deemed in the best interest of the Government, the contractor may be required to deliver the first article to the Government for testing. If this be the case, FAR clause 52.209-4 would be the appropriate clause to incorporate in the contract. The test requirements are normally specified in the TDP. The appropriate DIDs for a test plan and the test reports will be included in the DSL as category 1. The data delivery requirements will be included in the CDRL. Production items will not be accepted by the Government until the first article is approved. Any changes or repairs necessary to successfully complete the test will be accomplished by the contractor at no additional cost to the Government.

p. Quality Assurance Lot Verification Test (QALVT). A QALVT (formerly known as fly-to-buy) is performed by the Government on flight vehicles such as missiles and unmanned air vehicles. This is the final test performed prior to acceptance of the vehicles and is performed on items that have successfully completed all other in-plant specified inspections. The requirements include lotting, sampling, detailed procedures, referenced documents, plans, reports, inspect/reject criteria, environmental conditioning, Government and contractor responsibilities, corrective action, retest requirements, failure analyses, and delivery requirements for hardware and data. A number of cited documents and appropriate DIDs will be included in the DSL. Data delivery requirements will be included in the CDRL.

3-2.3.4 Production and Deployment Phase. Quality activities reach their peak during this phase as production steadily increases over a period of time from low rate initial production to full scale production. MIL-Q-9858 is imposed in its entirety, and the supplementary programs are in place and operating. Inspection increases dramatically, processes and process controls are in full swing, and process improvements are implemented. Government and contractor in-plant audits are conducted. Supplier quality control is intensified, and additional sources for components and other items are sought out and qualified. Poor performers are restricted or dropped. Government production lot tests are scheduled and conducted, and contract line items are accepted, placed in Army inventory, and eventually deployed to the field. Engineering activities are on-going. Redesigns are occurring in the form of product improvements and in response to changing mission requirements. The CCB activity continues to be intense as changes to the TDP are incorporated to facilitate production, to upgrade the design, and to correct errors. Inspection concepts are improved, resulting in changes to the SIE and the QEPL. Improvements are made to both the process control and ESS procedures. Failure analyses are conducted and corrective action taken. Field support documents and depot procedures are generated and validated, and depot IE is installed and validated. These activities and many more are taking place in this phase, with quality as either the leading element or as having a major supporting role. There are normally two system acquisition contracts, the production contract and an engineering services contract, for this phase of

the life cycle. The requirements that provide for the control of the production of hardware and for the administration and management of the production program are incorporated in the production contract. The requirements that provide for engineering activities in support of production are incorporated in the engineering services contract. In cases where there is no concurrent engineering services contract, the engineering support requirements are incorporated in the production contract. Many of the requirements imposed in the Engineering and Manufacturing Development phase contract are carried over into the Production and Deployment phase in one or the other of the two contracts. This section will address both production and engineering services requirements.

3-2.3.4.1 Production Requirements. The requirements normally imposed in a production contract where there is a concurrent engineering services contract are described in this paragraph. Where a requirement, such as quality reports, is imposed in both contracts, a narrative is included to specify that the reporting requirements of each contract should be combined in a single report. Depending on the nature of the procurement, some combination of the following requirements are imposed in a system acquisition production contract where a concurrent engineering services contract is in force.

a. **Quality Program Requirements.** MIL-Q-9858 is basically a production document and will be imposed in production contracts. A QPP will be required IAW the appropriate DID, and delivery requirements for the plan will be included in the CDRL. MIL-Q-9858 and the DID will be included in the DSL as category 2 and category 1, respectively. The processing of nonconforming material shall be IAW MIL-STD-480 which will be tailored in the DSL to delete all references to MIL-STD-1520. This tailoring disallows the repair of a major nonconformance and subsequent processing of the action (as a minor nonconformance) through the MRB without a MICOM approved repair procedure.

b. **Statistical Process Control (SPC).** The contractor shall implement and maintain the same program conceived, planned, implemented, and maintained in the Engineering and Manufacturing Development phase contract. Since contract requirements must stand alone without reference to other contracts, each contract must detail its requirements, even though the requirements might be a duplication of the requirements in previous contracts. The SOW directs what is to be incorporated into the program and requires that any changes must be approved by the Government. The ASQC B1, B2, and B3 documents will be included in the DSL as category 1. Since a SPC plan is required as a section in the QPP, no additional data delivery requirements will be required.

c. **Critical Safety Item (CSI) Program.** The contractor shall implement a CSI program IAW AMC-R 702-32, the SOW, and the TDP requirements. This program is basically a continuation of the program initiated in the Engineering and Manufacturing Development phase contract. However, it is tailored to drop the development related requirements and pick up the requirements applicable to production. The requirements relative to both phases are carried over into this contract. The contractor shall implement strict controls on the processes relative to the CSIs and shall perform 100% inspection of all CSIs. The most cost effective inspection methods and procedures for CSI characteristics and the effects of process changes on the CSI program shall be documented. A CSI program plan shall be required as a section in the QPP. The contractor shall evaluate, on a quarterly basis, the status of the CSI program relative to the CSI program plan. AMC-R 702-32 will be tailored for production and included in the DSL as category 2. Since a CSI program plan is required as a section in the QPP, no additional data delivery requirements will be required.

d. **Supplier Quality Control.** This requirement is basically the same as the requirement in the Engineering and Manufacturing Development phase contract. The activities necessary to accomplish effective supplier quality control do not vary between the two phases.

e. **Environmental Stress Screening (ESS).** The ESS procedures are designed and documented by this time. In order to conduct this program, the contractor shall acquire and utilize test jigs and fixtures IAW the TDP. The contractor shall monitor and provide continuous

improvements for the established program. Any changes to the ESS program shall receive Government approval prior to implementation.

f. Electrostatic Discharge (ESD) Sensitive Devices. The contractor shall manufacture, mark, and handle ESD sensitive devices IAW the requirements of MIL-STD-1686. The contractor shall document the methods and procedures for compliance in a plan prepared IAW the appropriate DID. MIL-STD-1686 will be tailored for only the applicable requirements and included in the DSL as category 2. The DID will be included in the DSL as category 1, and data delivery requirements will be included in the CDRL.

g. Inspection Equipment (IE). The IE requirements in the Production and Deployment phase contract are minimal since the design, development, documentation, calibration procedures, and validations are mostly complete. New development, redesign, and other engineering activities are accomplished under the engineering services contract. Only the acquisition, calibration, operation, and disposal of the IE are required under this contract. The contractor shall acquire, maintain, and disposition IE IAW MIL-I-45607. Calibration requirements will be specified by reference to MIL-STD-45662. The contractor shall implement a system that will prevent unauthorized tampering with the IE. The authorized removal or breaking of tamper proof devices is limited to Government inspection personnel and contractor quality personnel and must be documented each time it occurs. The IE shall be classified only as CIE, SIE or STE.

h. Training Program. The contractor shall develop a training program for personnel whose work has a significant effect on the quality of product. The program must include procedures for the certification and recertification of personnel whose work requires special skills. A training program plan and procedures for accomplishing the program shall be included in the QPP.

i. Quality Reports. This requirement will be carried over from the Engineering and Manufacturing Development phase contract. Monthly reports are generated for contract quality requirements to include the production quality, SPC, CSI, ESS, QAP and SIE development, and ESD programs. The contractor shall address problem areas, the causes and either the corrective action taken or the corrective action proposed. A statement will be included in the SOW for the contractor to combine the reporting areas of production and engineering services into a single report. The DID for the reports will be included in the DSL as category 1, and the data delivery requirements will be included in the CDRL.

j. Product Assurance Reviews. This requirement will be carried over from the Engineering and Manufacturing Development phase contract. The contractor shall conduct product assurance reviews each quarter that address the issues addressed in the quality reports plus any other areas required by MICOM. Appropriate DIDs will be included in the DSL as category 1 and in the CDRL to cover the agenda, presentation of material, and the minutes. A statement will be included in the SOW that requires the production and the engineering services organizations to present single combined reviews that address each of their activities and concerns.

k. First Article. This requirement will be carried over verbatim from the Engineering and Manufacturing Development phase contract since the first article may come either from prototypes made prior to production or from initial production units. The determination as to when the first article will be required must be made with each acquisition, and the QE must tailor the SOW as required. When the first article is required, the contractor must perform the tests as specified in the TDP IAW the first article clause of the contract (FAR clause 52.209-3). When deemed in the best interest of the Government, the contractor may be required to deliver the first article to the Government for testing. In this case, FAR clause 52.209-4 would be incorporated in the contract. Inspection requirements will be specified in the SOW, and the appropriate DIDs for a test plan and test reports will be included in the DSL, both as category 1. The data delivery requirements will be included in the CDRL. Production items will not be accepted by the Government until the first article is approved. If changes or repairs are necessary to successfully complete the inspection, they will be accomplished by the contractor at no additional cost to the Government.

l. Quality Assurance Lot Verification Test (QALVT). This requirement will also be carried over from the Engineering and Manufacturing Development phase contract. QALVT is normally initiated on prototype hardware produced under that contract and continued in the

Production and Deployment phase contract. The QALVT (formerly known as fly-to-buy) will be performed by the Government on flight vehicles such as missiles and unmanned air vehicles. This final test is performed prior to acceptance of the vehicles and is conducted on items that have successfully completed all other in-plant specified inspections. The requirements include lotting, sampling, detailed procedures, referenced documents, plans, reports, inspect/reject criteria, environmental conditioning, Government and contractor responsibilities, corrective action, retest requirements, failure analyses, and delivery requirements for hardware and data. The cited documents and appropriate DIDs will be included in the DSL and the data delivery requirements will be included in the CDRL. A number of the requirements addressed above require engineering services support, but are included herein since the overall effort is to determine acceptability of production hardware.

3-2.3.4.2 Engineering Services. The activities addressed in this section are normally imposed in engineering services contracts in support of a production effort where either a concurrent production contract or a concurrent basic ordering agreement (BOA) is in force. Engineering services are also frequently acquired for the support of fielded hardware. This type support is not discussed in this pamphlet.

a. Quality Program Requirements. The contractor shall implement and maintain a quality program IAW MIL-Q-9858, which assures the design of material that fulfills mission intent and is in conformance with technical and contractual requirements. A QPP IAW the appropriate DID shall be required. All available applicable documentation prepared under previous Government contracts that specified MIL-Q-9858 shall be utilized. Both MIL-Q-9858 and the DID will be tailored to engineering services requirements and incorporated in the DSL as category 2 and 1, respectively. The delivery requirements for the plan will be included in the CDRL. The processing of nonconforming material shall be IAW MIL-STD-480 which will be tailored in the DSL to delete all references to MIL-STD-1520. This tailoring disallows the repair of a major nonconformance and subsequent processing of the action (as a minor nonconformance) through the MRB without a MICOM approved repair procedure.

b. Critical Safety Item (CSI) Program. The contractor shall implement a CSI program that will assure the identification and control of CSIs and critical processes IAW the SOW and the TDP. The requirements were originated as guidelines in the Concept Exploration and Definition phase contract, firmed into hard requirements in the Engineering and Manufacturing Development phase contract, and carried over into the engineering services contract. These are the engineering requirements involved with the CSI program and include the identification and designation of CSIs, the characteristics and processes, the validation of requirements, the annotation of critical safety related drawings and specifications, the documentation of the effects of engineering changes on the CSIs, and the establishment of an executive level manager for the CSI program. The contractor shall document the CSI program plan as a section of the QPP. The items identified as CSIs shall be submitted under this contract IAW the appropriate DID. AMC-R 702-32 will be tailored to delete production type activities and will be included along with the DID in the DSL as category 2 and 1, respectively. The data delivery requirements for the CSI list will be included in the CDRL.

c. Environmental Stress Screening (ESS). The requirements for engineering activities relative to ESS are carried over from the Engineering and Manufacturing Development phase contract. This is necessary because design changes and changes in production processes will likely require new or redesigned ESS requirements, processes, profiles, and other changes. The ESS for redesigned or newly designed products shall be IAW MIL-STD-785, Task 301. The requirements also include a failure reporting, analysis, and corrective action system IAW MIL-STD-785, Task 104; the validation of redesigned or newly designed ESS test jigs and fixtures; the periodic evaluation of the effectiveness of procedures and recommendation of needed changes; the submission of periodic reports; the documentation of the ESS methods and procedures in a detailed plan and submission of it to MICOM for approval; and the quarterly evaluation of the ESS program relative to the plan. The contractor will also be required to develop drawings for any new test jigs

or fixtures made necessary by redesign of product or newly instituted screens. Both MIL-STD-785 and the DID will be tailored and included in the DSL as category 2 and 1, respectively. The data delivery requirements will be included in the CDRL.

d. Electrostatic Discharge (ESD) Sensitive Devices. The contractor shall manufacture, mark, and handle ESD sensitive devices IAW MIL-STD-1686. This requirement is included in the engineering services contract to cover ESD sensitive devices that may be utilized in the development of redesigned or newly designed prototype hardware. The contractor shall also annotate the drawings that are developed for redesigned or newly designed ESD sensitive product IAW DOD-STD-100. He shall document his methods and procedures for compliance in a plan prepared IAW the appropriate DID. DOD-STD-100, MIL-STD-1686, and the DID will be tailored, as necessary, and included in the DSL as category 2,2, and 1, respectively. The data delivery requirements will be included in the CDRL.

e. Quality Engineering Planning List (QEPL). The contractor shall update and maintain the QEPL IAW the appropriate DID and this pamphlet. This pamphlet and the DID will be tailored and included in the DSL as category 2 and 1, respectively. The data delivery requirements for the updated QEPL will be included in the CDRL.

f. Review of Technical Data. The contractor's QE element shall review and either approve or disapprove the ECPs, RFDs, and RFWs for their impact on quality. Where an ECP requires the generation of or revision to QAPs, that generation or change must be part of the ECP and, if approved, must be incorporated in the TDP IAW the SOW. The preparation of QAPs necessitated by an approved ECP will be addressed in the SOW. No documents will be listed in the DSL nor the CDRL for this requirement.

g. Inspection Equipment (IE). The same requirements imposed in the Engineering and Manufacturing Development phase contract for the acquisition of CIE and the design, documentation, fabrication, validation, and control of SIE and depot test equipment will be imposed in the engineering services contract. These requirements provide for the control of SIE generated as a result of redesign of product, new design of product, or changes in production procedures, production rates, or inspection methods. The contractor shall acquire, maintain, and disposition the IE IAW MIL-I-45607 and shall implement a system that will prevent unauthorized tampering of the IE. The authorized removal or breaking of tamper proof devices is limited to Government inspection personnel and contractor quality personnel and must be documented each time it occurs. The cited documents and appropriate DIDs will be included in the DSL, and the data delivery requirements will be included in the CDRL. The IE shall be classified as either CIE, SIE, or STE.

h. Inspection Equipment (IE) Software. Both DOD-STD-2167 and DOD-STD-2168 will be imposed as requirements in the SOW when it is anticipated that software for IE will be generated or revised. This includes nondeliverable software as well as deliverable and includes the software element of firmware. If the solicitation/contract includes a tactical software program, the SOW will state that the requirements for tactical software shall apply to the IE, and that the IE software shall be addressed in the tactical software quality program. If tactical software is not addressed in the quality program, the above standards will be included in the SOW and in the DSL as category 1. The contractor shall also prepare SIE software product specifications, including test/retest codes IAW the appropriate DID. The DID will be included in the DSL as category 1. The data delivery requirements will be included in the CDRL.

i. Quality Reports. This requirement in the engineering services contract will be basically the same as the one in the Engineering and Manufacturing Development and the Production and Deployment contracts. This requires monthly reporting from the contractor on all aspects of the quality program, such as production quality, SPC, CSI, ESS, QAP and SIE development, ESD programs, and each requirement of the SOW. The contractor shall assess the status of each aspect of the programs against the applicable plans. Problem areas, the causes, and the corrective action taken or proposed shall be addressed. A statement will be included in the SOW for the contractor to combine the reporting areas of engineering services and production into a single report. The DID for the reports will be included in the DSL as category 1, and the data delivery requirements will be included in the CDRL.

j. **Product Assurance Reviews.** This requirement in the engineering services contract will be the same as the one in the Engineering and Manufacturing Development phase contract. The contractor shall conduct product assurance reviews that address the issues addressed in the quality reports plus any other required areas on a quarterly basis. Three different DIDs will be included in the DSL as category 1 and in the CDRL to cover the agenda, presentation of material, and the minutes. A statement will be included in the SOW that requires the production and the engineering services organizations to present single combined reviews that address the activities and concerns of both organizations.

3-2.3.5 Follow-On Procurements. Previous sections of this chapter apply primarily to system/major item acquisition contracts that are awarded sole source to the prime contractor. When required, follow-on contracts for repair parts, also known as "secondary items or spares", are normally awarded during the Production and Deployment phase. Follow-on system acquisition production contracts may be awarded subsequent to the first production run. MICOM policy dictates that competitive sources be developed at the earliest opportunity for any item of product when it is beneficial to the Government. This effort, known as "breakout procurement", normally starts during the Production and Deployment phase and continues throughout the life of the system. Breakout procurement will be considered for all items of product at every generation level of a system, including the system itself. Items are exempt from breakout only when it can be clearly demonstrated to the Government that breakout is not beneficial. Some reasons that breakout may not be beneficial are proprietary rights, insufficient design disclosure, cost considerations, time constraints, and the unavailability of SIE. When such occasions arise, follow on procurements will be awarded to the prime contractor or other qualified sources.

3-2.3.5.1 Repair Parts/Secondary Items/Spares Procurements. The procurement of repair parts/secondary items/spares is generally necessary from production throughout the remainder of the system's life cycle. The initial stock is acquired from the prime contractor as either part of the production contract or a BOA. Subsequent buys will be accomplished either through a BOA or under the control of the MICOM Procurement Aging and Staging System (PASS), utilizing the MICOM Automatic Data Processing System for Technical Data Management and Engineering Reporting (MASTER) format as follows:

a. **Basic Ordering Agreement (BOA).** A BOA is a contractual document that invokes on the contractor many of the same types of technical, quality assurance, process control, program, administrative, legal requirements, and FAR clauses that are contained in the production contract. It applies to an identified system or group of items and is normally constrained by a price or quantity ceiling. The BOA may be used to buy a specified quantity of any identified item by execution of a procurement order that specifies the item, quantity, price, and delivery schedule. A BOA is usually awarded sole source to the prime contractor early in the Production and Deployment phase to meet the immediate need for spare parts when the system is first fielded. The QE requirements applicable to a BOA are essentially the same as those for a standard Production and Deployment phase SOW with the following exceptions:

(1) **SPC Program:** The requirement for a SPC Program is not generally required in a BOA because BOA items are normally manufactured on the same production line as the production items and are subject to the same SPC procedures as the production items. Even if this were not the case, SPC might not be required because it is not cost effective on small quantities of items as generally ordered under a BOA. Also, SPC training requirements are generally not specified since the employees would normally receive the necessary training under the requirements of the production contract. In cases where BOA quantities will likely warrant additional production facilities and personnel, the SPC program and training requirements will be incorporated in the BOA.

(2) First Article. A first article is normally not required since the prime contractor has complied with first article requirements under the production contract and has been in continuous production ever since.

(3) Quality Assurance Lot Verification Test (QALVT). A QALVT requirement is normally not imposed in a BOA since the follow-on procurement of flight vehicles is accomplished with a follow-on production contract and not with a BOA.

b. Procurement Aging and Staging System (PASS) Actions. In the PASS, each repair part procurement has its own procurement package. PASS action procurement packages are circulated to MICOM technical and quality organizations for their review to either determine that the item can be competitively procured or suggest ways that the package may be upgraded so that it can be competitively procured. The procurement packages consist of the TDP, the MASTER format, and the applicable FAR clauses. The QAPs are usually specified on the drawings or in the specifications, and the quality requirements are usually on the MASTER format. The requirements on the MASTER format include first article requirements, contract quality requirements (MIL-Q-9858, MIL-I-45208, standard inspection requirement or the contractor inspection requirement), and point of inspection and acceptance (source or destination). The criteria for making these determinations are the same as previously stated for system and major item contracts. Of primary interest to the QE Division, PAD, is whether or not the QAPs are adequate for competition, whether or not SIE is specified, and whether or not an alternate test method using CIE is specified. If either the QAPs are inadequate for competition or a test method using CIE is not specified, the procurement must be restricted to the original contractor. PAD is responsible for providing the quality inputs to the MASTER format. The prime contractor may participate in all competitive procurements except for the procurement of items set aside for small business.

c. Follow-on System and Major Item Procurements. Where conditions warrant, follow-on production contracts for weapon systems and major items will be awarded by competitive procedures in which the prime contractor may participate. The SOW requirements, as specified in the original production contract, are generally applicable to follow-on procurements. A first article requirement will be required of new contractors but may be waived for the prime contractor if he has been in continuous production and has had a good quality history since successfully completing the original first article requirement. Where conditions prohibit competitive procurement, follow-on contracts will be awarded to the original contractors.

3-3 QAPS IN TECHNICAL DATA PACKAGES (TDPs)

3-3.1 Introduction.

3-3.1.1 A major function of the QE Division, PAD, is to ensure the development of effective QAPs and their incorporation into the TDP. The QE Division also has the responsibility of reviewing the TDP to assure that specified materials and processes are correct and adequate, parts are properly specified, dimensions are complete and correct, tolerances are realistic and correctly specified, technical requirements are stated in a manner where they can be accurately inspected and determined to conform or nonconform, and QAPs are complete and correctly stated. This effort is accomplished in support of the configuration management element during the Engineering and Manufacturing Development phase and culminates in a functional configuration. The PCA leads to a product configuration identification and the release of the TDP to Government configuration control. The QE Division, PAD continues to support the configuration management activity throughout the system's life cycle as a member of the CCB.

3-3.1.2 QAPs define the minimum inspections that the contractor must perform and the minimum controls that must be maintained to assure that the item meets the documentation requirements. The Government will not accept any known defects but, as evidenced by allowing sampling inspection, is sometimes willing to accept some level of risk of the existence of unknown defects. Although sampling inspection is sometimes allowed, all sampling plans must be designed

for the acceptance of lots where sampling indicates zero defects and for the rejection of lots where sampling indicates one or more defects.

3-3.1.2.1 The format and requirements to be used in the development of specifications are prescribed in MIL-STD-490 and MIL-STD-961. MIL-STD-490 is to be used for program peculiar specifications, and MIL-STD-961 for specifications for items having wide spread application.

3-3.1.2.2 QAPs will be placed in each specification or on each drawing in a separate note titled "Quality Assurance Provisions". If necessary, additional sheets may be added to the drawing to accommodate the QAPs. There must be QAPs to verify each critical and each major characteristic and, if necessary, the minor characteristics. Minor characteristics that do not have specific QAPs for their verification will be subject to inspection under the contractor's inspection system or quality program.

3-3.2 Classification of Characteristics/Defects.

3-3.2.1 Definitions are as follows:

a. **Characteristic.** A feature, function, property, or attribute of a product, material, or process which is necessary to achieve fitness for use and has been specified for inclusion in QAPs.

b. **Classification of Characteristics/Defects.** The enumeration of characteristics or possible defects of the unit of product classified according to their seriousness. Characteristics/defects will normally be grouped into classes of critical, major, or minor.

c. **Critical Characteristic/Defect.** A characteristic/defect that judgment and experience indicate is likely to either result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product or prevent performance of the tactical function of a major end item such as an aircraft, communication system, land vehicle, missile, ship, space vehicle, surveillance system, or major part thereof.

d. **Defect.** Any nonconformance of a characteristic with specified requirements. (The classification of a defect is the same as the classification of the characteristic that nonconforms to its requirements.)

e. **Defective.** A unit of product which contains one or more defects.

f. **Major Characteristic/Defect.** A characteristic/defect other than critical that is likely to result in failure or to reduce materially the usability of the unit of product for its intended purpose.

g. **Minor Characteristic/Defect.** A characteristic/defect that is not likely to reduce materially the usability of the unit of product for its intended purpose or is a departure from established standards, but has little bearing on the effective use or operation of the unit.

3-3.2.2 **Objectives of Classification.** The classification of characteristics is required as one of the first steps in preparing QAPs. The characteristics, or possible defects, are to be identified and classified into critical, major, or minor as defined above and in MIL-STD-109. This function is best accomplished as a joint effort by the contractor's QE and design engineering personnel. The objectives of classification are as follows:

a. To identify the specific characteristics that require inspection in order to determine product conformance.

b. To differentiate between the more important quality properties and those of lesser importance so that a rational assessment can be made of the consequences of nonconformance.

c. To indicate the stage of manufacture or assembly at which the characteristics are to be examined or tested and to facilitate the inspection reporting.

d. To provide an economical means of inspection without jeopardizing quality.

e. To determine the level, MRB or CCB, at which defectives may be dispositioned.

3-3.2.3 Identification of Characteristics. When it is determined that the classification of characteristics is essential to the inspection procedure, the classification will be included either in section 4 (the QAPs section) of a specification, on drawings, or in other documents as appropriate. The classification of characteristics requires a thorough engineering knowledge of the design and use of the product, and sound analysis and judgment for each characteristic. Characteristics will be classified and numbered as follows for identification and reporting purposes:

C1, C2, etc. --- for Critical Characteristics
 M1, M2, etc. --- for Major Characteristics
 X1, X2, etc. --- for Minor Characteristics

3-3.2.3.1 Characteristics shall be specified by placing a QAP symbol (Figure 3-3.1) on the drawing. The QAP symbol shall be placed IAW DOD-STD-2101 next to each critical and major characteristic.

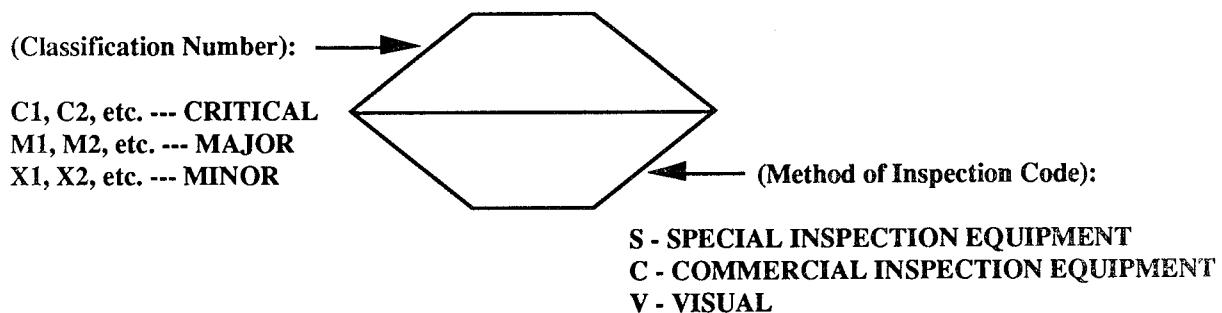


Figure 3-3.1 QAP Symbol

3-3.2.3.2 The use of the QAP symbols and classification of characteristics shall be explained by placing QAP notes and legends on the drawings. The classification of characteristics shall be C1, C2, etc., or X1, X2, etc. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified by this symbol. All other characteristics are subject to being inspected under the contractor's quality program or inspection system.

3-3.2.4 Developing and Revising Classifications. The following will be considered in developing or revising the classifications:

a. A ranking of characteristics according to their relative importance to end item requirements shall be performed prior to finalizing the classification. The characteristics are normally classified during the Engineering and Manufacturing Development phase. This classification shall be a team effort to include contractor design engineering, manufacturing engineering, and QE personnel. The classification decisions shall be documented on the drawing as part of the preliminary TDP pending finalization of the formal classification. The classification of characteristics will form a basic tool for, and shall be utilized by, the QE throughout the product's life cycle. The classification provides a means for planning the QA effort that will eventually be reflected in section 4 of specifications, on drawings, and in other documents.

b. Caution must be exercised to assure that the final classification of characteristics provides a means of accepting or rejecting product based on the requirements of sections 3 and 5 of the specifications or the drawings. A duplication of the same requirement in the specification or on the drawing shall be avoided unless it is necessary to inspect for a defect at multiple levels of manufacture or assembly. The contractor is responsible for complying with requirements from component level up to, and including, the end item. Care must be taken to assure that characteristics that cannot be inspected at the assembly level are inspected prior to assembly. Generally, it is more economical to inspect for each defect at the lowest possible level of manufacture.

c. Inspection records and test reports generated during the development, production and procurement of an item can provide beneficial information. If analyzed correctly, the data can likely help pinpoint probable causes of defects. The item itself should also be examined before the classification is finalized, for it may reveal additional features important to the classification.

3-3.2.5 Standards for Defects. Standards shall be specified to provide as much objectivity as possible for inspection decisions regarding defects such as cracks, chips, scratches, digs, and any others that require judgment. The standards may be descriptive and will be especially beneficial if they provide pictorial or other kinds of illustrations of various type defects. They should provide a means of judging when a condition is normal and acceptable and when it reaches unacceptable limits. For example, some surface scratches on an item may be acceptable within certain limits but unacceptable outside the limits. These criteria shall be included in the QAPs.

3-3.2.6 Sampling Provisions. Sampling plans which influence the contractor to maintain close control over the quality of the product shall be developed. Plans which permit the acceptance of a lot when the sample contains defects shall not be used. Such plans infer that it is permissible to tender defective material to the Government which, as stated earlier in this pamphlet, is not so. For critical and major characteristics, both 100% inspection and the use of automatic test equipment to the maximum extent possible should be specified. If sampling inspection is specified, sampling plans with zero accept numbers only shall be used. The terms "AQL" and "LTPD" shall not be used in the sampling plans and the sampling plans must be approved by PAD.

3-3.2.7 Inspection Verification Cross Reference Index. The functional requirements shall be compiled in a tabular listing of verification methods, test categories, classification of characteristics, inspection levels, and references as depicted by Table 3-3.1. The inspection characteristics shall be either adequately described or referenced to the requirement (specification paragraph number or drawing note or zone) and to the applicable inspection procedure (specification paragraph number or drawing note).

3-3.3 QAPs in Specifications.

3-3.3.1 General. This section provides guidance in the application of QAPs in section 4 of specifications. Where a specification is required for an item, all QAPs, including those verifying drawing requirements, must be included in section 4 of the specification. Furthermore, a note referencing the specification such as, "This item shall be in accordance with MIS-XXXXX" must be placed on the drawing. The specification must be listed on the parts list as a referenced document.

3-3.3.2 Types of specifications. The following types of specifications cover the principal Army material development and acquisition phases. Inspection provisions suitable for each phase must be included to assure that all requirements are achieved.

- Type A - System specifications
- Type B - Development specifications
- Type C - Product specifications

Table 3-3.1. Inspection Verification Cross Reference Index

Verification methods legend: (see 6.3.4)				Test category legend:						
Requirement Reference	1	2	3	4	A	B	C	Class charac.	Inspection Level	Inspection Reference
3.2.1.1.1 Output voltages	X				X	X				4.3.2.5
3.2.1.1.2 Coolant	X				X	X				4.3.2.6
3.2.1.2 Activation current	X				X	X				4.3.2.4
3.2.1.3 Match resistance	X				X	X	X	101	100%	4.3.2.1
3.2.1.4 Actuator bridge-wire resistance	X				X	X	X	102	100%	4.3.2.2
3.2.1.5 Insulation resistance	X				X	X	X	103	100%	4.3.2.3
3.2.1.6 Safety device	X				X			106	c = 0 ^{4/}	4.3.2.7
3.2.2.1 Weight					X			201	c = 0 ^{4/}	4.3.1.1
3.2.2.2 Dimensions					X	X	X	X	104	4.3.1.2
3.2.2.3 Expended battery					X	X	X	X	105	100% ^{1/}
Indication										4.3.1.5
3.2.3.1.1 Humidity	X				X					4.4.1.1
3.2.3.1.2 Transportaton vibration	X				X	X				4.4.1.2
3.2.3.1.3 Shock	X				X					4.4.1.3
3.2.3.1.4 Temperature shock	X				X	X				4.4.1.4
3.2.3.1.5 Immersion	X				X	X	X	107		4.4.1.5 ^{3/}
3.2.3.1.6 High temperature	X				X					^{2/}
3.2.3.1.7 Low temperature	X				X					^{2/}
3.2.3.2.1 High temperature, operating	X				X	X				4.4.2.1
3.2.3.2.2 Low temperature, operating	X				X	X				4.4.2.2
3.3.1 Production drawings			X		X	X				4.3.1.3
3.3.2 Workmanship				X	X	X	X	202	100%	4.3.1.4
5. Preparation for delivery				X	X		X	203	c = 0 ^{4/}	4.3.1.6

^{1/} Verify nonactivated indication.^{2/} This requirement is satisfied by the accumulation of time from all other tests involving this requirement.^{3/} For quality conformance inspection, the inspection method shall conform to the requirements given in 3.2.3.1.5(a).^{4/} Sampling plan must provide for acceptance on zero defects/rejection on 1 or more defects. Sampling plan must be approved by the Government.

Type D - Process specifications
Type E - Material specifications

a. System specification. This type of specification contains the technical and mission requirements for a developmental item or system as an entity. The requirements must be maintained current throughout the Concept Exploration and Definition phase, culminating in documentation that forms the functional base for the system and, through allocation, its subsystems. System specifications define the system's functional base line and are normally released at the end of the Concept Exploration and Definition phase.

b. Development specification. The requirements for the design of an item during its developmental period are contained in this type specification. Each development specification must be in sufficient detail to effectively describe the performance characteristics that each configuration item must achieve in order to evolve into a design of sufficient detail for production. Development specifications are normally released at the end of the Demonstration and Validation phase to form the system's allocated baseline.

c. Product specification. This type of specification is applicable to any item below the system level. It may be oriented towards procurement of a product through the stipulation of either functional (performance) requirements or fabrication (detailed design) requirements. Product specifications are normally released at the end of the Engineering and Manufacturing Development phase and forms the system's product baseline.

d. Process specification. When a process such as heat treatment, soldering, welding, plating, and bonding is performed on a product, it will be documented in a process specification. Process specifications also cover critical manufacturing operations, where strict process control is essential to insure uniform quality.

e. Material specification. Material specifications cover the manufacture of raw materials, compounds, and mixtures which are used in the fabrication of a product.

3-3.3.3 A product type specification is utilized in the following paragraphs to illustrate the basic format, content, and relationship of the various sections of the specification.

3-3.3.3.1 Format. A specification will normally be arranged in six sections numbered and titled as follows:

- Section 1 - Scope
- Section 2 - Applicable Documents
- Section 3 - Requirements
- Section 4 - Quality Assurance Provisions
- Section 5 - Preparation for Delivery
- Section 6 - Notes

3-3.3.3.2 Content. The general content of each section of a specification is provided in the following paragraphs. The information shows the relationship of QAPs within the entire specification. It is not intended to be used in the preparation of specifications.

a. Section 1 - Scope. This section provides a clear, concise abstract of the coverage of the specification.

b. Section 2 - Applicable Documents. This section lists the documents referenced in the other sections and in the appendices. The sections where the documents are referenced specify the applicability of these documents.

c. Section 3 - Requirements. This section specifies the requirements (description, system design, materials, performance characteristics, processes, reliability, and workmanship) which the product must meet. The requirements represent the actual needs of the Government to satisfy the intended use and application and are to be defined in a manner that would encourage competition. Each requirement must be necessary, clear, complete, practicably attainable, and capable of being

demonstrated as accomplished. Each one must be self sufficient and stated in terms which are independent of inspection methods and procedures. The requirements must provide a definitive basis for acceptance or rejection and must be described so that each characteristic can be evaluated. Performance (functional and operational) requirements must not be omitted on the assumption that engineering drawings are sufficiently definitive or that the contractor's quality control function will be sufficiently effective. Furthermore, the requirements shall not be omitted solely because testing is expensive or time consuming.

d. Section 4 - Quality Assurance Provisions (QAPs). This section provides both the responsibility for inspection and the inspections (examinations or tests) to be performed in order to determine whether or not the item conforms to the requirements in sections 3 and 5. Every effort shall be made to design the section 4 QAPs with a reasonable balance between the expenditure of resources (time and money) and risks.

e. Section 5 - Preparation for Delivery. This section includes the requirements for preservation, packing, packaging, and marking of packages and containers. They must be necessary, clear, complete, and practicably attainable.

f. Section 6 - Notes. This section contains information of a general or explanatory nature such as intended use, ordering data, administrative instructions for first article samples (if any), definitions, and miscellaneous notes.

3-3.3.3.3 Relationship of Section 4 to Sections 3 and 5. Quality results from the conformance of product to the specified requirements of sections 3 and 5 of the specification. The QA element must verify that quality with the inspection of the product IAW the QAPs (inspection procedures) of section 4. Section 3 must not differentiate between production items and inspection samples with respect to product requirements. Both the production items and inspection samples to be delivered under the contract shall meet all of the requirements of the specification. Production items are expected to perform interchangeably with first article, qualification, comparison, or other inspection samples. The fact that certain inspections are conducted on a limited sampling basis, as prescribed in section 4, has no effect on the requirements of section 3. In order to differentiate between the requirements of section 3 and the QAPs of section 4, the specifying of requirements as quality instructions is to be avoided. Statements such as, "each item shall be subjected to..." or "the mean daily rate shall be computed..." are not requirements but procedural instructions and should not be a part of section 3. Section 3 necessarily includes the conditions relating to the performance requirements but not to the methods and procedures by which these conditions are attained.

3-3.3.3.4 Relationship of Section 4 to Section 6. The coverage in section 4 may require appropriate supplementary notes (instructions) in section 6. Two examples are instructions in case a first article is a contractual requirement and instructions for applying a particular option that may be provided in section 4.

3-3.3.4 Coverage of Specifications. Specifications may be generated to cover either a group of products (general) or a single product (detail). These two types are defined as follows:

a. General Specifications. This type of specification covers requirements common to two or more types, classes, grades, or styles of specific items or processes. This avoids the repetition of common requirements that exist in detail specifications. It also permits changes to common requirements to be more readily effected. General specifications may also cover common requirements for weapon systems and subsystems. They and their attendant detail specifications are more commonly used for military specifications of widespread application than for MISs.

b. Detail Specifications. There are two types of detail specifications. One type contains all of the requirements needed to cover one or more types of items or services and, therefore, stands alone. In such cases, there are no associated general specifications. The other type is incomplete without the general specification which contains the common requirements. Detail specifications may be prepared either in the section format or in the simplified specification sheet format. The

specification sheet format is used when requirements are more appropriately presented in tabular or graphic form. In most instances, a single specification sheet will cover a number of items differing only in one or two characteristics such as length, diameter, ohmic value, etc. Only one style, type, or model of an item will be covered by a detail specification (specification sheet format) having an associated general specification. The specification sheet format will not be intermixed with section format specifications.

3-3.3.5 Specifications Relative to the TDP. Specifications are a part of the TDP. The TDP also consists of technical data such as plans, drawings, and associated lists. The QAPs in section 4 of a particular specification shall be tailored to the relationship of that specification with the other documents in the TDP.

3-3.3.6 Specifications Relative to Contracts. Just as the TDP becomes part of the contract, specifications, as part of the TDP, also become a part of the contract. The specification may be modified or even deleted by the contract (FAR clauses, SOW, data items, etc.). There must be a compatible interplay between the specification, the contract, and contract administration to define the product to be procured, to assure the product conforms to specified requirements, and to assure that the product is delivered to the Government within a specified time.

3-3.3.7 Scope and Content of Section 4 of Specifications.

3-3.3.7.1 General. Section 4 of program peculiar specifications provides the general scope, responsibilities, and contents of QAPs. It provides the minimum inspections the contractor must perform to insure that the product conforms to the requirements in sections 3 and 5.

3-3.3.7.2 Responsibility for Inspection. Section 4 must clearly state the contractor's responsibility for inspection IAW the Responsibility for Inspection clause stated in MIL-STD-490. This section also reserves the Government's right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

3-3.3.7.2.1 Enforcement of the contractor's responsibility is dependent on adequate contractual requirements and the administration of those requirements by the Government. Inspection clauses incorporated in the contract must be consistent with contractor responsibilities as stated in FAR clause 52.246-1.

3-3.3.7.2.2 Section 4 does not include contractual requirements relating to inspection responsibility. These requirements are a part of the contract. However, both contractual and administrative provisions considered essential for inspection responsibility may be indicated in Section 6 as ordering data or other features to be included in contracts. This provision must be exercised with caution and be limited to essential matters.

3-3.3.7.3 Inspection Conditions. When it is necessary to establish conditions under which inspection methods are to be conducted, section 4 will specify these conditions. The conditions may either be general to all inspection methods or apply to a particular method. When chemical, toxic, explosive, or other hazardous material is involved, a note of warning must be stipulated.

3-3.3.7.4 Inspection Equipment (IE). The specific IE to be used shall be specified to the degree necessary, to include the identification of CIE and SIE. Section 4 shall indicate that the contractor is responsible for having available, or making arrangements for the use of, suitable facilities in which the prescribed examinations and tests will be conducted. The part number of the SIE shall be the same as the Army part number of the item that it is used in the inspection of preceded by the acronym "SIE". Where the SIE is used in the inspection of more than one item

with different part numbers, the SIE will have its own unique part number preceded by the acronym "SIE".

3-3.3.7.5 Inspection Methods. The inspection methods that will assure conformance to the requirements in sections 3 and 5 shall be included in section 4. The methods provide a means of assuring that the examinations and tests are properly conducted. Examination and test methods that appear in standards and other documents and are appropriate may be included by reference. Where SIE is specified and when possible, an alternate but substantially equivalent inspection method using CIE shall be specified. Inspection methods utilizing SIE shall be specified by reference to the SIE EOIs. Inspection methods utilizing CIE shall consist of detailed step by step procedures.

3-3.3.7.6 Inspection Verification Cross Reference Index. A cross reference index shall be included in all specifications. The example in Table 3-3.1 is self explanatory except for the following:

a. The inspection level column must provide a reference to the level of inspection required, either 100% inspection, the sampling plan to be used, or where a SPC system is in effect. Footnotes shall be used where appropriate.

b. Both FAT samples and PCI samples must successfully complete the QCI prior to starting the FAT or the PCI except when the QCI is destructive. A paragraph to this effect shall be included in Section 4. It is possible that some inspections may be checked in the QCI column but not in the FAT nor PCI columns.

3-3.3.7.7 Preparation of Section 4. The preparation and arrangement of section 4, as presented in the following paragraphs, shall be followed to the maximum extent practicable. However, since some specifications produce their own unique problems and conditions, it may be necessary to tailor them to the situation. The following paragraphs are numbered as they would be in section 4 of a specification. When paragraphs must be added or deleted, the following paragraphs shall be renumbered accordingly.

a. Responsibility for Inspection. Each specification shall include in the beginning of Section 4 the following paragraph and, when appropriate, paragraph 4.1.1.

"4.1 Responsibility for Inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may utilize his own facilities or any other facilities acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements."

"4.1.1 Government Responsibility. The Government shall be responsible for the performance of the tests in paragraph 4.-.-."

NOTE: When it is deemed necessary for the Government to perform any inspection requirement exclusively, it must be indicated in this paragraph. The Government's responsibility shall be tailored to the activity, such as a specific proving ground test or a periodic conformance test, and shall include such things as contractor witnessing, extent of contractor support and liaison, equipment to be supplied by the contractor, and test location.

b. Classification of Inspections. When Section 4 of a specification includes inspections other than QCIs, a classification of inspections must be included. The inspections for each classification shall be covered by a separate paragraph as follows:

"4.2 Classification of Inspections. The inspection requirements specified herein are classified as follows:

- (a) Qualification Test.
- (b) First Article Test.
- (c) Periodic Conformance Inspection.
- (d) Quality Conformance Inspection.
- (e) Packaging Inspection."

c. Inspection Conditions. If necessary, the conditions under which the above inspections are conducted shall be specified as follows:

"4.3 Inspection Conditions. Unless otherwise specified for a particular inspection, all examinations and tests shall be performed within the following conditions:

(a) Temperature range:	18 degrees to 35 degrees Celsius 65 degrees to 95 degrees Fahrenheit .
(b) Relative humidity:	Up to 95 percent.
(c) Barometric pressure:	Local average plus or minus 2 inches of mercury."

d. Toxicological Data and Formulations. When section 3 of the specification specifies a requirement for the review of product with toxicological data, the following statement must be included in section 4:

"4.4 The contractor shall furnish the toxicological data and formulations required to evaluate the safety of the material for the proposed use."

e. When toxic, explosive, or other hazardous materials are involved, the following type precautionary note must be included:

"CAUTION - This specification covers the inspection of materials (chemical, toxic, or explosive) which are potentially hazardous to personnel. All applicable safety rules, regulations, and procedures shall be followed in the handling and processing of these materials."

f. First Article Test (FAT) (paragraph 4.5). When section 3 of the specification requires a first article, section 4 shall include a description of the FAT, the sequence of the inspections and tests, data required, and the criteria for determining conformance to the requirements. Generally, a tabular form of presentation will allow a better understanding of the following:

- (1) The correlation between the requirements of section 3 and the inspection criteria of section 4 (Table 3-3.1).
- (2) The relationship of the FAT to the PCI and the QCI (Table 3-3.1).
- (3) The sequence of tests. This paragraph must specify the number of items to be tested and, if a pilot lot is to be used, must specify the size of the pilot lot and the method of choosing the test samples.

g. Periodic Conformance Inspection (PCI) (paragraph 4.6). When specified as a requirement in section 3, section 4 must include a description of the inspections, the sequence of inspections, data required, the criteria for determining conformance to the requirements, the actions to be taken in case of failure, the number of samples to be tested, and the frequency of the tests. As with first articles, a tabular form of presentation (Tables 3-3.1 and 3-3.2) will promote a better understanding of the test criteria. Each table can address both FATs and PCIs. This paragraph must also specify the action to be taken in case of failure, the status of the lot with the failed item, and the status of subsequent lots.

Table 3-3.2 Environmental/Performance Inspections

Environmental Inspections	NON-OPERATING					OPERATING		
	Humidity (see 4.4.1.1)	Transportation vibration (see 4.4.1.2)	Shock	Temperature shock (see 4.4.1.4)	Immersion (see 4.4.2.1)	High temperature (see 4.4.2.1)	Low temperature (see 4.4.2.2)	Ambient (see 4.1.1.1)
Performance Inspections								
Output voltages (see 4.3.2.5)						D	D	D
Coolant (see 4.3.2.6)						D	D	D
Activation current (see 4.3.2.4)						D	D	D
Match resistance (see 4.3.2.1)	A	A	A	A	A			
Actuator bridgewire resistance (see 4.3.2.2)	A	A	A	A	A			
Insulation resistance (see 4.3.2.3)	A	A	A	A	A			
Dimensions (see 4.3.1.2)						B	B	B
Expendable battery indication (see 4.3.1.5)	A	A	A	A	A	A	A	A

A = after environment

B = before environment

D = during environment

h. Quality Conformance Inspection QCI) (paragraph 4.7). This section must list all inspections required to verify that the product offered for acceptance has achieved the requirements of sections 3 and 5. These inspections are as follows:

(1) Inspection Lot Formation. When inspections are to be based on lots or samples from lots, a definition of what constitutes a lot must be furnished in section 4. Restrictions regarding the formation of lots such as limiting the lots to like units (same type and class) must be specified. An example of a lot formation paragraph is as follows:

"4.7.1 Inspection Lot Formation. An inspection lot shall consist of those like items produced at the same place utilizing the same batches of materials, lots of components, process runs, fabrication techniques, assembly methods, tools, equipment, and facilities, but shall not exceed one week's production."

(2) Inspection Sampling. The inspection sampling procedure must clearly identify the sampling plan to be used at intermediate points in the manufacturing process and on the end item. If a standard sampling plan is selected, it must clearly identify the applicable sampling table from MIL-STD-105, MIL-STD-414, or other sampling plans approved by the Government. The appropriate inspection level and sampling plan (see Appendix C) shall be specified as per the following examples:

"4.7.2 Sampling. Sampling for quality conformance inspections shall be in accordance with MIL-STD-105. Critical characteristics must undergo 100% inspection except where the inspection is destructive. Major characteristics shall be accepted on zero defects and rejected on one or more defects. Minor characteristics shall be inspected in accordance with the contractor's approved inspection system."

"4.7.3 Quality Conformance Inspection. Quality conformance inspections shall be as specified in Table 1."

(3) Classification of Characteristics. A classification of characteristics is to be included in Table X of section 4 (Table 3-3.1).

(4) Preparation for Delivery Inspection. The inspections to determine conformance with the preservation, packaging, packing, and marking requirements of section 5 of the specification must be listed, either directly or by reference. In many instances, this may be accomplished by referencing packaging specifications or packaging data sheets in the classification of characteristics. An example of an appropriate paragraph to be used in a product specification is as follows:

"4.7.4 Packaging Inspection. The preparation for delivery inspections shall be as specified in this paragraph and (specify the classification of characteristics table or the inspection verification cross reference index table).

4.7.4.1 Packaging and Packing. Verify the item is packaged and packed in accordance with the (designate the procuring agency) approved packaging data sheet.

4.7.4.2 Marking for Shipment. Verify that the item has been marked for shipment in accordance with MIL-STD-129, "Marking for Shipment and Storage," and, if applicable, verify that critical safety items are marked in accordance with contractual requirements."

i. Methods of Inspection (paragraph 4.8).

(1) The IE (paragraph 4.8.1). The IE required to perform the specified inspections shall be identified and related to each inspection characteristic as appropriate. This may cover the broad scope from CIE to SIE. A statement regarding the contractor's responsibility for the supply, maintenance and calibration of the IE shall also be included. An example of an appropriate paragraph is as follows:

"4.8.1 Inspection Equipment. Unless otherwise specified, the contractor shall furnish the following inspection equipment and shall use it in the performance of the inspections specified herein. If equivalent equipment is proposed, it must be approved by the Government prior to use.

- (a) One Control Assembly.
Test Console, SIE-12XXXXXX.
- (b) One Electronic Counter.
Accuracy: 0.3 parts per million per month.
(Hewlett-Packard, Model 5315A or equivalent).
- (c) One Multimeter.
Accuracy: $\pm 5\%$
(Simpson, Model 260 or equivalent)."

(2) Inspection Methods (paragraph 4.8.2). The methods of inspection must include the number of examinations and tests, test equipment and materials, test routine, number of samples, and other applicable considerations. Inspection methods must be under the specific classification of inspection headings such as FAT, QCI, or the general heading "Inspection Methods." The latter is preferred where inspections are extensive or common to other classifications. The specific test requirements and corresponding test methods are best correlated by tabulation (reference paragraph 3-3.3.7.6 above and Table 3-3.1 as examples).

3-3.4 QAPs on Drawings.

3-3.4.1 QAPs must be prepared and placed on drawings for components, subassemblies, and assemblies that do not require a specification but have detailed technical requirements that affect reliability, interchangeability, function, or safety. In cases where the engineering requirements and the QAPs clutter the drawing making it difficult to follow or interpret, the development of a specification should be reconsidered.

3-3.4.2 QAPs must be specified on the drawing as a separate note under the heading "Quality Assurance Provisions" and shall include either a classification of characteristics table or the QAP symbols (see Figures 3-3.2A and 3-3.2B respectfully). Under this heading, the following must be incorporated as applicable:

- a. The FAT requirements, procedures, and required inspection equipment.
- b. Classification of characteristics.
- c. Approved sampling plans to include lotting requirements.
- d. The QCI requirements, procedures, and required inspection equipment.

3-3.4.2.1 The classification of characteristics tables and the QAP symbols shall be used to identify critical and major characteristics, the type of IE required (CIE or SIE), and the level of inspection (100% or sampling) required. The drawing note or zone where the characteristic is located shall be identified in the classification of characteristics table when a table is used in lieu of the symbols.

3-3.4.2.2 When SIE is used to conduct an inspection, the SIE part number must be identified in the QAPs for the particular characteristic to be inspected.

3-3.4.2.3 Critical characteristics require 100% inspection unless the inspection is destructive. Major characteristics should be considered for 100% inspection unless the inspection is destructive. All other (minor) characteristics are subject to being inspected under the contractor's quality program or inspection system.

D

21. QUALITY ASSURANCE PROVISIONS:

A. FIRST ARTICLE TEST - THE FIRST ARTICLE TEST AS DESCRIBED BELOW SHALL BE SUCCESSFULLY COMPLETED PRIOR TO COMMENCING PRODUCTION UNLESS OTHERWISE DIRECTED IN THE CONTRACT OR SOLICITATION. SIX ITEMS, HAVING SUCCESSFULLY PASSED THE INSPECTIONS OF NOTE 21. B, SHALL BE CONDITIONED TO THE REQUIREMENTS OF NOTE 13, AND SUBJECTED TO THE FUNCTIONAL TESTS OF NOTE 21. C. THE FUNCTIONAL TESTS SHALL BE PERFORMED AT THE SPECIFIED HIGH TEMPERATURE, LOW TEMPERATURE, AND AT AMBIENT TEMPERATURE. NO FAILURES ARE ALLOWED.

B. CLASSIFICATION OF CHARACTERISTICS

<u>CLASS</u>	<u>CHARACTERISTIC</u>	<u>ZONE</u>	<u>INSPECTION METHOD</u>
<u>CRITICAL</u> NONE	100% INSPECTION ---		
<u>MAJOR</u>	100% INSPECTION		
M1	FUNCTIONS	NOTE 10	TEST, NOTE 21.C.
M2	INSTALLATION AND CONDITION OF SPECIFIED COMPONENTS	P/L, NOTE 4, LAYOUT	VISUAL
<u>MINOR</u>	ALL CHARACTERISTICS NOT IDENTIFIED ABOVE ARE CONSIDERED MINOR. THESE CHARACTERISTICS ARE SUBJECT TO INSPECTION UNDER THE CONTRACTORS QUALITY PROGRAM OR INSPECTION SYSTEM.		

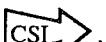
C. ACCEPTANCE TESTS

(1) ALL ACCEPTANCE TESTS WILL BE CONDUCTED IAW MIS-XXXXX

D. CERTIFICATION: PRIOR TO ACCEPTANCE, THE SUPPLIER SHALL CERTIFY THAT ALL REQUIREMENTS FOR PARTS, MATERIALS, AND FINISHES SPECIFIED ON DRAWING XXXXXXXX AND ITS ASSOCIATED DRAWINGS, LISTS, AND DOCUMENTS HAVE BEEN COMPLIED WITH. TEST DATA NECESSARY TO VERIFY SUCH COMPLIANCE SHALL BE PRESENTED WITH THE CERTIFICATION.

A

E. ENVIRONMENTAL STRESS SCREENING WILL BE CONDUCTED IAW MIS-XXXXX.

F. CRITICAL SAFETY CHARACTERISTICS ARE INDICATED WITH THE SYMBOL .

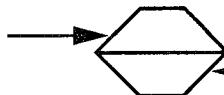
D

21. QUALITY ASSURANCE PROVISIONS:

A. FIRST ARTICLE TEST - THE FIRST ARTICLE TEST AS DESCRIBED BELOW SHALL BE SUCCESSFULLY COMPLETED PRIOR TO COMMENCING PRODUCTION UNLESS OTHERWISE DIRECTED IN THE CONTRACT OR SOLICITATION. SIX ITEMS, HAVING SUCCESSFULLY PASSED THE INSPECTIONS OF NOTE 21. B, SHALL BE CONDITIONED TO THE REQUIREMENTS OF NOTE 13, AND SUBJECTED TO THE FUNCTIONAL TESTS OF NOTE 21. C. THE FUNCTIONAL TESTS SHALL BE PERFORMED AT THE SPECIFIED HIGH TEMPERATURE, LOW TEMPERATURE, AND AT AMBIENT TEMPERATURE. NO FAILURES ARE ALLOWED.

B. CLASSIFICATION OF CHARACTERISTICS

(Classification Number):



(Method of Inspection Code):

C1, C2, etc. --- CRITICAL (100% Inspection)
 M1, M2, etc. --- MAJOR (100% Inspection)
 X1, X2, etc. --- MINOR *

S - SPECIAL INSPECTION EQUIPMENT
 C - COMMERCIAL INSPECTION EQUIPMENT
 V - VISUAL

* (All characteristics not identified by this symbol are considered MINOR. These characteristics are subject to inspection under the contractors quality program or inspection system.)

B

C. ACCEPTANCE TESTS

(1) ALL ACCEPTANCE TESTS WILL BE CONDUCTED IAW MIS-XXXXXX



D. CERTIFICATION: PRIOR TO ACCEPTANCE, THE SUPPLIER SHALL CERTIFY THAT ALL REQUIREMENTS FOR PARTS, MATERIALS, AND FINISHES SPECIFIED ON DRAWING XXXXXXXX AND ITS ASSOCIATED DRAWINGS, LISTS, AND DOCUMENTS HAVE BEEN COMPLIED WITH. TEST DATA NECESSARY TO VERIFY SUCH COMPLIANCE SHALL BE PRESENTED WITH THE CERTIFICATION.

E. ENVIRONMENTAL STRESS SCREENING WILL BE CONDUCTED IAW MIS-XXXXXX.

A

F. CRITICAL SAFETY CHARACTERISTICS ARE INDICATED WITH THE SYMBOL



Figure 3-3.2B QAPs on Drawings (Symbol Format)

3-3.4.2.4 When the drawing permits sampling, the characteristics must be grouped on the drawing and be assigned the specific sampling criteria as it applies to the Government approved SPC plan or sampling plan. The sampling plan to be used must be Government approved and require rejection on one or more defects and acceptance on zero defects only.

3-3.4.2.5 The statement that all characteristics not classified herein (minor) are subject to inspection under the contractor's quality program or inspection system must be included.

3-3.4.2.6 The characteristics of CSIs that have been identified as critical shall be identified on the drawing by placing the CSI symbol (Figure 3-4.1) adjacent to the characteristic. A box with the words "CRITICAL SAFETY ITEM" shall be placed on the drawing above the title block IAW DOD-STD-100.

3-3.4.3 Where applicable, notes shall specify ESS, CSI, ESD, soldering, PWA and PWB requirements. These notes would not appear in the QAP notes but would appear as separate notes on the drawing.

3-3.4.4 Drawings with notes requiring compliance with material or process specifications containing a section titled "Quality Assurance Provisions" shall not contain a classification of characteristics table. The QAPs within such material or process specifications control all required inspections. If tighter controls or inspections are required for a specific application, the requirement should be stated in an engineering note with the change of inspection criteria specified in the QAPs.

3-3.4.5 Characteristics shall not be specified for inspection if they are as follows:

- a. Provided only for producibility or manufacturing convenience.
- b. Covered by adequate inspection requirements prescribed in a specification that is referenced on the drawing.
- c. Minor characteristics.

3-3.4.6 When a drawing contains only minor characteristics, and no characteristic requires a greater emphasis than the others, the following note shall be placed on the drawing:

"Quality Assurance Provisions. All characteristics are subject to inspection under the contractor's quality program or inspection system."

3-3.4.7 The ESS TDP requirements shall be documented as a MIS and the MIS referenced on each applicable drawing. The ESS requirements for all PWBS, shop replaceable units, line replaceable units, sub-system levels, and system levels will be documented in the ESS MIS. The ESS MIS shall be revised accordingly as the production processes improve or deteriorate during production. All changes are subject to Government approval.

3-4 QAPS IN MAINTENANCE, STORAGE, AND FIELD DOCUMENTATION

3-4.1 General. The DMWRs and SSSs are equipment publications that provide technical guidance in the documentation of the maintenance support structure designed during development of the maintenance support effort. They also provide technical guidance for the operation, examination, test, evaluation, maintenance, and repair parts support of the materiel system, including modifications accomplished under modification work orders (MWOs). These documents must include QAPs to insure the quality of operations performed during and after the Production and Deployment phase of the materiel's life cycle. The QE activities associated with the development, preparation, review, and validation of these documents are as follows:

3-4.1.1 QAPs in DMWRs. The DMWRs must be prepared IAW MIL-M-63041. This document requires the inclusion of statements such as the requirement for a QA plan, contractor/depot responsibility for quality, the processing of waivers, and certification requirements. QAPs that are prepared for the end item TDP should be used where applicable in the preparation of DMWRs. Areas of concern regarding quality are contained throughout the DMWRs. Some of these that are of concern to the QE involved in the review and validation of the DMWRs are as follows:

- a. Warning Pages. Warning pages must be included for items such as CSIs and ESD sensitive devices. Figures 3-4.1 and 3-4.2 are examples of these warning pages.
- b. Chapter 1. This chapter contains information regarding the reporting requirements for Equipment Improvement Reports, Quality Deficiency Reports, RFDs, RFWs, and ECPs as required by DA Pamphlet 738-750, AMC-R 702-7, MIL-STD-480 and MIL-STD-481 respectively. This chapter also includes the general requirements of DESCOM-R 702-1 for the processing of RFDs and RFWs.
- c. Chapter 2. Items of interest to the QE in this chapter are:
 - (1) Facilities. Includes test cells, clean rooms, environmental facilities, etc.
 - (2) Tools and Equipment. Includes separate sections on CIE and SIE to include EDs, CPs, and EOIs. Examples of CIE lists and SIE lists are contained in MIL-M-63041. A statement should be added that the SIE requires validation by the procuring agency's quality element.
 - (3) Parts and Materials. Includes a mandatory statement that parts and materials used shall meet production drawing/specification requirements unless otherwise stated.
 - (4) The ESD Sensitive Devices. If the item is ESD sensitive, a program for ESD prevention IAW MIL-STD-1686 and DOD-HDBK-263 shall be required.
 - (5) The CSIs. If the item is a CSI, a program IAW AMC-R 702-32 shall be required.
- d. Chapter 3. This chapter includes instructions for inspection of the item for shipping damage and for verifying the reported failures. Also included are checklists in sequence of operations to record all preshop inspections and analyses. Detailed procedures for the inspections must be either included or referenced.
- e. Chapter 4. This chapter includes the following:
 - (1) QAPs shall be included or referenced in this chapter. Illustrations of equipment such as "special equipment and tools" and "what to use for measurements" shall also be included. In-process inspection requirements and overhaul inspection procedures with accept/reject criteria shall be included. This section of the DMWR is of utmost importance to QA, since it establishes specific pass/fail limits. In-process inspections shall be highlighted by the addition of the abbreviation "QA" at the beginning of each QA step or procedure. Tolerances, wear limits, test equipment standards, and instructions and accept/reject data for diagnostic inspection procedures shall be included. Inspection to a specified AQL is allowed in field support documents since the materiel already belongs to the Army and acceptance of production items is not involved. An example of an overhaul inspection procedure is contained in MIL-M-63041.
 - (2) Disassembly instructions must have inspection requirements inserted as required with pass/fail criteria. Cleaning requirements, inspection instructions, and criteria of the overhauled item must be included.
 - (3) The last section of this chapter shall contain the final inspection instructions prior to the test/performance checks. The detailed test/performance instructions such as special tests, adjustments permitted during test, burn-in requirements, environmental effects, SIE operating instructions, and a checklist for acceptance showing each required test are also included in this section. This section is of paramount importance in assuring adequate quality and should be reviewed in detail by the QE.

WARNING

CRITICAL SAFETY ITEM

WARNING

The Assembly covered by this DMWR has been identified in accordance with AMCR 702-32 as a Critical Safety Item (CSI). Nonconformance to critical safety item characteristics identified in drawings and specifications will result in an UNSAFE condition.

Critical Safety Characteristics will be indicated with the following symbol adjacent to the dimension, process, note, or other critical safety requirement:



This Operation is Critical

Figure 3-4.1 Warning. Critical Safety Item



CAUTION

The assembly covered by this DMWRs contains static-sensitive components which must be protected from damage due to static electricity.

Whenever work or adjustments are performed within the deenergized assembly, the assembly must be grounded and personnel must wear grounded antistatic wrist straps.

If any internal component or integrated circuit is touched or is suspected of having been touched when grounded wrist straps were not being worn, immediate or delayed damage may have occurred.

The assembly must be placed in static shield bags when internal components are exposed and work is not being performed.

Figure 3-4.2 Caution. Electrostatic Discharge Sensitive

f. Chapter 5. Section I of this chapter covers contractor/depot responsibility for quality; definitions; special instructions for the design, maintenance, calibration and disposition of IE; comparison standards reference table; certification requirements; and QA plan requirements. Many statements are mandatory and must be used verbatim. However, the QE should review this chapter and make certain the following areas are adequately addressed:

- (1) Contractor/depot responsibility for inspections and calibrations.
- (2) Maintenance, calibration, and disposition of the IE.

(3) Certification of personnel skills, procedures, processes, materials, and equipment by the contractor/depot. Special certifications are required for such skills as soldering, ESD, nondestructive testing, and welding.

(4) The QA plan covering the work required by the DMWRs and the contract/work directives is the responsibility of the contractor/depot QA activity. The depots will prepare the plan IAW DESCOM-R 702-1. Contractor operated depots shall conform to either MIL-Q-9858 or MIL-I-45208 as required. The QA plan will be made available to the requiring activity for review prior to the start of work and throughout the life of the program. The depot will notify the requiring activity in writing of any changes made to the plan. The basic plan and changes thereto are subject to disapproval by the requiring activity. In addition to the requirements of the foregoing references, the plan must provide for the following:

- (a) Comparison inspection standards to be coordinated with the requiring activity.
- (b) Nonacceptance of material/procedural departures from the DMWRs or supporting specifications without prior approval of the requiring activity IAW MIL-STD-481.
- (c) Rejected material to be randomly inspected to verify classification prior to reclamation or disposal.
- (d) Maintenance and reclamation procedures to be verified before and periodically during operations.
- (e) Inspection requirements to be accomplished as required.

- (5) Initial reconditioning inspection (First Article, AR 702-10).

(a) Requirements. The first article (initial overhauled, rebuilt, or repaired units) shall be submitted for inspection IAW the contract. The first article shall be overhauled, rebuilt, or repaired in the same manner, using the same materials, equipment, processes, and procedures as used in the regular overhaul, rebuild, or repair program. All parts and materials, including packaging and packing, shall be obtained from the same supply source as used in the regular overhaul, rebuild, or repair programs.

(b) Time. The appropriate Government element shall be notified 30 days in advance so that the inspection may be witnessed.

(c) Responsibility. When responsible for the FAT, the contractor shall conduct the inspections at the contractor's facility or at a contractor operated depot to assure that the first article conforms to the requirements of the contract. The contractor shall then submit a record of the inspection and the certificates of conformance for the materials used in the overhaul, rebuild, or repair to the Government for approval/disapproval. The Government reserves the right to witness the contractor conducted FATs.

(6) In-Process Inspections. As stated above, the minimum required in-process inspections are identified throughout the DMWRs by the addition of the abbreviation "QA" at the beginning of each procedure. Additional inspections may be established by the depot as necessary.

(7) Acceptance Inspections. Acceptance of all items processed IAW the DMWRs will be based on the following:

- (a) Compliance with quality of material requirements.
- (b) Compliance with the requirements of in-process inspections.
- (c) Compliance with the requirements of the final acceptance inspection and for the final assembly inspection.
- (d) Proper preparation for shipment and storage.

g. Validation of DMWRs. MIL-M-63041 includes intensive contract language as to the validation of DMWRs by the contractor with the Government reserving the right to witness the validation. The document also addresses the Government's right to review drafts, and have representatives conduct operating, maintenance, and calibration procedures as presented in the DMWRs. The validation of DMWRs is a vital part of the overall QA process, and every effort should be made by the QE to participate in this program.

3-4.1.2 QAPs in Storage Serviceability Standards (SSSs). The Army's objective is to attain and maintain a constant materiel readiness status of supplies and equipment in depot storage. The SSSs contain instructions for the inspection of items in storage in order to determine their serviceability and to insure that the materiel is maintained in a ready to use condition. These instructions encompass the preservation, packaging, and marking requirements, the storage criteria, and the time/phasing for inspection during the storage cycle. The documents are also used to determine if shelf life items have retained their original characteristics and are of a quality level which warrants extension of their shelf life period. The SSSs are the responsibility of the development command and are transitioned with transfer of logistics responsibility. The regulation AMC-R 702-23 prescribes the policies, responsibilities, and procedures for the development and preparation of SSSs.

3-4.1.3 The SSS Requirements.

a. The SSSs specify the AQL to which deterioration can progress without an unacceptable loss of product serviceability.

b. The SSSs shall be prepared, maintained, and revised for items that are susceptible to deterioration in the following priority sequence:

- (1) Type II shelf life items (extendable)(Ref. AR 700-89).
- (2) Material having critical characteristics that require control while in storage to assure proper functioning in later service. These materials are identified under the Special Control Item Code program (Ref. AMC-R 702-23), or the CSI program (Ref. AMC-R 702-32).
- (3) Principal items (Ref. AR 700-89).
- (4) Items identified as Type 1 (nonextendable) for which the accumulation and analysis of relevant data is required to support an adjustment in the shelf life.

c. The SSS supply bulletins must include as many applicable items as possible and contain two sections (Section I, Introduction and Section II, Storage and Special Instructions) and as many appendices as necessary to include applicable stock numbered items.

3-4.1.4 Content and Format of SSSs. The SSS supply bulletins must contain the following information (Ref. AMC-R 702-23):

a. Section I - Introduction. This section must provide the administrative and general information required for one to properly interpret and use the SSS and must include the following:

- (1) Purpose. The purpose for which the SSS information and guidance are intended.
- (2) Scope. The functional areas (storage and issue) and the applicable items or categories of items covered by the SSS.

(3) Definitions. The words and terms necessary to assure proper interpretation and use of the information contained in the SSS.

(4) Other. The instructions required to accomplish the stated purpose.

b. Section II - Storage and Special Instructions. This section must provide storage information and special instructions pertaining to the commodity or to a family of items in storage (either by reference or detailed instruction) as follows:

(1) Deterioration limits for the materiel, criteria for adjusting inspection frequency, examination and test requirements, shelf-life codes (AR 700-89), sampling and lotting requirements, forms and references, precautionary information, stages of corrosion, and any other instruction that might be required during storage.

(2) Explanation of the codes shown in Figure 3-4.3.

c. Coded Standards. The SSSs must contain coded data utilizing the format prescribed in Figures 3-4.3 and 3-4.4 and the following instructions:

(1) National Stock Number (NSN) (column *a*). The first four digits of the NSN are known as the Federal Stock Class number. These numbers will appear as the first entry in column *a* on each page. The last nine digits of the NSN are known as the National Item Identification Number. These numbers will be printed as follows:

(a) A series of numbers shall be printed in groups of five as follows. A blank space will separate each group.

6675-00-057-8717
-00-065-7505
-00-065-8525
-00-076-3187
-00-077-2622

6675-00-137-7317
-00-174-0515
-00-183-6485
-00-184-5783
-00-866-3217.

(b) Consecutive NSN entries with identical data may be simplified by printing only the first and last numbers of the series as follows. A blank space will separate each group.

6675-00-164-4565 through 6675-00-165-6460.

(c) When many stock classes can be coded as a group, the initial entry may be used for the class. After this, the word "except" will be entered, and the exceptions will then be listed in consecutive numerical sequence in groups of five as follows:

5305-Except
-00-190-2145
-00-222-3747

(2) Item Name (column *b*). This entry will consist of the condensed form (21 characters or less) of the federal item identification. It contains the basic noun of the item.

(3) Quality Defect Codes (column *c*). These codes will be used to alert quality control personnel to characteristics which require special attention and to establish a basic groundwork for inspection. Quality defect codes consist of three digits. The first digit of the code is the severity of the defect: 0 - critical, 1 - major, and 2 - minor. The following two digits indicate the sequence of the severity of each characteristic.

(4) Inspection Level (column *d*). Inspection levels will be selected from MIL-STD-105 by the commodity command preparing the SSS. Special inspection levels will be designated as S1, S2, S3, and S4 and general inspection levels will be designated as G1, G2, and

NATIONAL STOCK NUMBER a	ITEM NAME b	QUAL DEF CODE c	IL d	CRITICAL e	AQL e	MAJOR * f	SLC f	IFC g	TRC h	PC i	TSG j
1450-00-											
867-3982	Gasket	111 113 123 133 141 142 151	S1		.4%	0	3	00V	X	B	
867-6535	Hood Assy.	102 111 113 123	S1		.4%	0	3	00V	X	C	
867-6540	Power Supply	01 02 113 123 141 145 151	G2	100%	.4%	0	3	00V	A	C	
6920-00											
928-6053	Gage	01 113 123 133	G2	100%	.4%	0	3	00V	X	C	
930-7491	Thermostat	102 111 112 123 141 151	G2		.4%	0	3	00V	X	B	
7650-00											
065-8525	Illuminator	01 123 133 141	G2	100%	.4%	0	5	00V	A	C	
321-8795	Bumper, Rubber	102 123 133 141 143 151 155	G2		.4%	3	3	00V	X	B	
334-4174	Case, Sketch	101 123 133 141 143 151 155	S2		.4%	5	5	00V	B	C	
8010-00											
161-7254	Primer	113 133 142 150	S2		.4%	1	1	00K	X	D	
247-4336	Pigment	133 133 142 150	S2		.4%	3	1	0KE	X	D	
558-7207	Thinner	113 133 142 150	S2		.4%	3	1	0KD	X	D	

* All major AQLs are grouped for characteristics shown.

Figure 3-4.3 Sampling Format Codes Standards

NATIONAL STOCK NUMBER a	ITEM NAME b	QUAL DEF CODE c	AQL MAJOR d	CRITICAL e	TSG PC TRC IFC SLC f	To be designated by the responsible commodity command.
						To be designated by the responsible commodity command.
						To be designated by the responsible commodity command.
						AR 740-1.
						AR 700-89 and the AMDF.
						To be designated by the responsible commodity command.
						To be designated by the responsible commodity command.
						To be designated by the responsible commodity command.
						As designated by DESCOM Reg 702-1
						As designed for the AMDF.

Figure 3-4.4 Source of Codes for Coded Standards

G3. Inspection levels will be specified to obtain the smallest possible sample size consistent with the quality requirements. Samples will be taken from homogeneous lots.

(5) Acceptable Quality Level (AQL) (column *e*). An AQL will be selected from MIL-STD-105 that will assure a realistic probability that the Army materiel issued to users will be serviceable. Grouped AQLs will be provided for major defects, where applicable.

(6) Shelf Life Code (column *f*). Alphanumeric shelf-life codes will be assigned to items to indicate their storage time period and shelf life type as assigned by the commodity command. These codes are provided in AR 700-89 and in the Army Master Data File (AMDF) for individual items. For items where age is computed by quarter, the quarter in which the item was manufactured is not counted. Such items are not to be considered one-quarter year old until the end of the succeeding quarter. Example: An item manufactured in the fourth quarter, 1990, was considered one-quarter year old on 31 March 1991. When an item shows only the month and year of the shelf-life expiration date on the label, the shelf life of the item expires on the last day of that month.

(7) Inspection Frequency Code (column *g*). All items in storage are subject to inspection. The frequency of inspection is based upon the criticality of the item and the storage environment. Table 8-1 of AR 740-1 establishes minimum inspection frequencies for items when they do not have either an assigned shelf life or a predetermined inspection period. Inspection frequency codes apply to items scheduled to be inspected at regular intervals. Their codes are based upon storage environments and are included in SSSs as guidance for storage activities. Variances in inspection frequencies will be made on an item by item basis by the commodity commands and will be provided in writing to depots or other storage installations. The inspection frequency codes relative to the frequency of inspections are as follows:

<u>Inspection Frequency Codes</u>	
Code	Frequency (months)
1	6
2	12
3	24
4	30
5	60

(8) Test/Restorative Action Code (TRC) (column *h*).

(a) These coded inspection requirements (column *c*) are general requirements and may not produce enough information to permit material serviceability determinations or, in the case of type II shelf life items, may not sufficiently describe the tests nor the restorative actions needed to extend the shelf life material. When more detailed inspection instructions are required, they will be written in the format shown in Figure 3-4.5 and included in a separate appendix of the appropriate SSS. A unique, individual TRC number will be used to index each instruction. The instructions should be general enough to include as many lines as possible to avoid repetitious instructions. The major subordinate command will not assign the same TRC number to more than one inspection instruction.

(b) The TRC will be a three-digit alphanumeric number. To avoid confusion in interpreting the codes, alpha characters "O" and "I" will not be used. Groups of codes may be assigned or reserved by the major subordinate command, as required, except as in paragraph (c) below.

(c) Some items that are not complicated require only simple examination. To cover these items, the following codes apply:

Inspection	TRC	Nondestructive	OON
Dimensional	OOD	Pressure	OOP
Functional	OOF	Tensile	OOT
Hardness	OOH	Visual	OOV

Laboratory	OOL	Weight	OOW
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(9) Packaging code (column *i*). The following alpha codes represent the minimum level of protection required for the storage conditions described in paragraph (10) below. Packaging codes contained in SSS appendices are required to set the inspection frequency described in paragraph (7) above. If material received for storage is preserved at a level other than that described in column *i*, the inspection frequency will be adjusted accordingly.

Code Level of Protection

- A. Maximum Military Protection
- B. Minimum Military Protection
- X. Commercial

SUPPLEMENTARY QUALITY ASSURANCE INSPECTION INSTRUCTIONS

Supply Bulletin Number and Test/Restorative Action Code:

COMMAND ADDRESS:

1. Purpose. The purpose of the supplementary inspection instructions will be provided in this paragraph.
2. Policy. The general and specific commodity command policy regarding the supplementary instructions will be provided in this paragraph.
3. Supplementary Instructions. General instructions covering classification of defects, sampling, AQLs, shelf- life, inspection frequency, TRC, packaging, and type storage are provided in the SSS. If inspection instructions, in addition to the test/restorative action instructions provided in the SSS, are required, they will be provided in this paragraph. Furthermore, if reference data are necessary for the accomplishment of the test/restorative action, it should also be listed in this paragraph.

Figure 3-4.5 Test/Restorative Action Code (TRC) Inspection Instruction Format

(10) Type storage code (column *j*). The type of storage codes contained in SSS appendices are required to set the inspection frequency described in paragraph (7) above. If materiel is stored in an environment other than as described in column *j*, the inspection frequency will be adjusted accordingly. The following alpha and numeric codes represent the minimum level of storage environment required for the level of preservation and the inspection frequency provided in paragraphs (7) and (9) above.

<u>Code</u>	<u>Explanation</u>
A	Heated warehouse space (general purpose)
B	Unheated warehouse space (general purpose)
C	Controlled humidity warehouse space
D	Flammable warehouse space
E	Chill warehouse space
F	Freeze warehouse space
G	Shed, nonwarehouse space
M	Wet storage space
Q	Hazardous commodity space (non-class V items such as acids, compressed gasses, and radioactive material)
T	Controlled humidity, nonwarehouse space
U	Other nonwarehouse space
X	Special storage at 35 degrees F (20 degree C) or less
O	Open, concrete, improved space
2	Open blacktop, improved space
4	Open, crushed stone, improved space
6	Open, gravel, improved space
8	Open, unimproved space
9	Preservation and packing or maintenance space

APPENDIX A REFERENCE DOCUMENTS

DOCUMENTS

MIL-I-45208	INSPECTION SYSTEM REQUIREMENTS
MIL-I-45607	INSPECTION EQUIPMENT, ACQUISITION, MAINTENANCE, AND DISPOSITION OF
MIL-M-63041	MANUALS, TECHNICAL; DEPOT MAINTENANCE WORK REQUIREMENTS
MIL-Q-9858	QUALITY PROGRAM REQUIREMENTS
MIL-T-31000	GENERAL SPECIFICATION FOR TECHNICAL DATA PACKAGES

HANDBOOKS

DOD-HDBK-263	ELECTROSTATIC DISCHARGE CONTROL HANDBOOK FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES AND EQUIPMENT
MIL-HDBK-204	INSPECTION EQUIPMENT DESIGN

PHAMPLETS

DA-P 738-750	FUNCTIONAL USERS MANUAL FOR THE ARMY MAINTENANCE MANAGEMENT SYSTEM (TAMMS)
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POLICIES

MICOM POLICY 702-3	INSPECTION EQUIPMENT FOR MICOM WEAPON SYSTEMS
MICOM POLICY 702-18	COMPONENT SAFETY

REGULATIONS

FAR 9.202	GENERAL (QUALIFIED PRODUCTS)
FAR 9.301	DEFINITIONS (FIRST ARTICLE TESTING AND APPROVAL)
FAR 13.000	SMALL PURCHASE AND OTHER SIMPLIFIED PURCHASE PROCEDURES
FAR 45.101	DEFINITIONS (GOVERNMENT PROPERTY)
FAR 46.101	DEFINITIONS (QUALITY ASSURANCE)
FAR 46.2	CONTRACT QUALITY REQUIREMENTS
FAR 52.209-3	FIRST ARTICLE APPROVAL - CONTRACTOR TESTING
FAR 52.209-4	FIRST ARTICLE APPROVAL - GOVERNMENT TESTING
FAR 52-245-18	SPECIAL TEST EQUIPMENT
FAR 52.246-1	CONTRACTOR INSPECTION REQUIREMENTS
FAR 52.246-2	INSPECTION OF SUPPLIES - FIXED PRICE
FAR 52.246-3	INSPECTION OF SUPPLIES - COST REIMBURSEMENT
FAR 52.246-4	INSPECTION OF SERVICES - FIXED PRICE
FAR 52.246-5	INSPECTION OF SERVICES - COST REIMBURSEMENT
FAR 52.246-6	INSPECTION - TIME AND MATERIAL AND LABOR HOUR
FAR 52.246-7	INSPECTION OF RESEARCH AND DEVELOPMENT - FIXED PRICE
FAR 52.246-8	INSPECTION OF RESEARCH AND DEVELOPMENT - COST REIMBURSEMENT
FAR 52.246-9	INSPECTION OF RESEARCH AND DEVELOPMENT (SHORT FORM)
FAR 52.246-10	INSPECTION OF FACILITIES
FAR 52.246-11	HIGHER-LEVEL CONTRACT QUALITY REQUIREMENT (GOVERNMENT REQUIREMENT)
FAR 52.246-16	RESPONSIBILITY FOR SUPPLIES

REFERENCE DOCUMENTS (continued)

AR 700-89	IDENTIFICATION, CONTROL AND UTILIZATION OF SHELF-LIFE ITEMS
AR 702-10	POST-PRODUCTION TESTING OF ARMY MATERIEL
AR 740-1	STORAGE AND SUPPLY ACTIVITY OPERATIONS
AMC-R 10-80	MISSION AND MAJOR FUNCTION OF THE US ARMY MISSILE COMMAND
AMC-R 702-7	LOGISTICS PRODUCT ASSURANCE
AMC-R 702-10	QUALITY ASSURANCE PROVISIONS FOR ARMY MATERIEL
AMC-R 702-23	STORAGE SERVICEABILITY STANDARDS
AMC-R 702-32	CRITICAL SAFETY ITEM PROGRAM
DESCOM-R 702-1	DESCOM PRODUCT ASSURANCE PROGRAM

STANDARDS

DOD-STD-100	ENGINEERING DRAWING PRACTICES
DOD-STD-2101	CLASSIFICATION OF CHARACTERISTICS
DOD-STD-2167	DEFENSE SYSTEM SOFTWARE DEVELOPMENT
DOD-STD-2168	DEFENSE SYSTEM SOFTWARE QUALITY PROGRAM
MIL-STD-105	SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES
MIL-STD-109	QUALITY ASSURANCE TERMS AND DEFINITIONS
MIL-STD-129	MARKING FOR SHIPMENT AND STORAGE
MIL-STD-414	SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY VARIABLES FOR PERCENT DEFECTIVE
MIL-STD-454	STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT
MIL-STD-480	CONFIGURATION CONTROL - ENGINEERING CHANGES, DEVIATIONS AND WAIVERS
MIL-STD-481	CONFIGURATION CONTROL - ENGINEERING CHANGES (SHORT FORM), DEVIATIONS AND WAIVERS
MIL-STD-490	SPECIFICATION PRACTICES
MIL-STD-785	RELIABILITY PROGRAM FOR SYSTEMS AND EQUIPMENT, DEVELOPMENT AND PRODUCTION
MIL-STD-961	MILITARY SPECIFICATIONS AND ASSOCIATED DOCUMENTS, PREPARATION OF
MIL-STD-1235	SINGLE AND MULTI-LEVEL CONTINUOUS SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES
MIL-STD-1520	CORRECTIVE ACTION AND DISPOSITION SYSTEM FOR NONCONFORMING MATERIAL
MIL-STD-1535	SUPPLIER QUALITY ASSURANCE PROGRAM REQUIREMENTS
MIL-STD-1686	ELECTROSTATIC DISCHARGE CONTROL PROGRAM FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES AND EQUIPMENT
MIL-STD-45662	CALIBRATION SYSTEMS REQUIREMENTS

INDUSTRY STANDARDS

ANSI STD 716-1985	C/ATLAS TEST LANGUAGE
ANSI STD 1012-1986	STANDARD FOR SOFTWARE VERIFICATION AND VALIDATION PLANS
ASQC B1-85	GUIDE FOR QUALITY CONTROL CHARTS
ASQC B2-85	CONTROL CHART METHOD OF ANALYZING DATA
ASQC B3-85	CONTROL CHART METHOD OF CONTROLLING QUALITY DURING PRODUCTION

APPENDIX B

ACRONYMS

AMC	ARMY MATERIEL COMMAND
AMDF	ARMY MASTER DATA FILE
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
ASQC	AMERICAN SOCIETY FOR QUALITY CONTROL
AQL	ACCEPTABLE QUALITY LEVEL
AR	ARMY REGULATION
BOA	BASIC ORDERING AGREEMENT
CCB	CONFIGURATION CONTROL BOARD
CDRL	CONTRACT DATA REQUIREMENTS LIST
CIE	COMMERCIAL INSPECTION EQUIPMENT
CIVR	CONFIGURATION ITEM VERIFICATION REVIEW
CP	CALIBRATION PROCEDURE
CSI	CRITICAL SAFETY ITEM
DA	DEPARTMENT OF THE ARMY
DCMC	DEFENSE CONTRACTS MANAGEMENT COMMAND
DESCOM	DEPOT SYSTEM COMMAND
DID	DATA ITEM DESCRIPTION
DMWR	DEPOT MAINTENANCE WORK REQUIREMENT
DOD	DEPARTMENT OF DEFENSE
DSL	DOCUMENT SUMMARY LIST
DWG	DRAWING
ECP	ENGINEERING CHANGE PROPOSAL
ED	EQUIPMENT DESCRIPTION
EOI	EQUIPMENT OPERATING INSTRUCTION
ESD	ELECTROSTATIC DISCHARGE
ESS	ENVIRONMENTAL STRESS SCREENING
FAR	FEDERAL ACQUISITION REGULATION
FAT	FIRST ARTICLE TEST
FCA	FUNCTIONAL CONFIGURATION AUDIT
IAW	IN ACCORDANCE WITH
IE	INSPECTION EQUIPMENT
IFB	INVITATION FOR BID
IFTE	INTEGRATED FAMILY TEST EQUIPMENT
LCL	LOWER CONTROL LIMIT
LSL	LOWER SPECIFICATION LIMIT
LTPD	LOT TOLERANCE PERCENT DEFECTIVE
MASTER	MICOM AUTOMATIC DATA PROCESSING SYSTEM FOR TECHNICAL DATA MANAGEMENT AND ENGINEERING REPORTING
MICOM	MISSILE COMMAND
MIS	MISSILE SPECIFICATION
MRB	MATERIAL REVIEW BOARD
MTBF	MEAN TIME BETWEEN FAILURE
MWO	MODIFICATION WORK ORDER
NSN	NATIONAL STOCK NUMBER
OC	OPERATING CHARACTERISTIC
PAD	PRODUCT ASSURANCE DIRECTORATE
PASS	PROCUREMENT AGING AND STAGING SYSTEM
PCA	PHYSICAL CONFIGURATION AUDIT
PCI	PERIODIC CONFORMANCE INSPECTION
PECT	PERIODIC ENVIRONMENTAL CONFORMANCE TEST
PET	PERIODIC ENVIRONMENTAL TEST
PRVT	PERIODIC RELIABILITY VERIFICATION TEST
PWA	PRINTED WIRING ASSEMBLY
PWB	PRINTED WIRING BOARD

ACRONYMS (continued)

QA	QUALITY ASSURANCE
QALVT	QUALITY ASSURANCE LOT VERIFICATION TEST
QAP	QUALITY ASSURANCE PROVISION
QCI	QUALITY CONFORMANCE INSPECTION
QE	QUALITY ENGINEER (ING)
QEPL	QUALITY ENGINEERING PLANNING LIST
QPP	QUALITY PROGRAM PLAN
QVI	QUALITY VERIFICATION INSPECTION
RFD	REQUEST FOR DEVIATION
RFP	REQUEST FOR PROPOSAL
RFW	REQUEST FOR WAIVER
SIE	SPECIAL INSPECTION EQUIPMENT
SOW	STATEMENT OF WORK
SPC	STATISTICAL PROCESS CONTROL
SQA	SOFTWARE QUALITY ASSURANCE
SSS	STORAGE SERVICEABILITY STANDARD
STE	SPECIAL TEST EQUIPMENT
TDP	TECHNICAL DATA PACKAGE
TQM	TOTAL QUALITY MANAGEMENT
TRC	TEST/RESTORATIVE ACTION CODE
UCL	UPPER CONTROL LIMIT
USL	UPPER SPECIFICATION LIMIT
UUT	UNIT UNDER TEST

APPENDIX C

SAMPLING TO A SPECIFIED AQL

This method of sampling is the most common method of sampling because of the influence and convenience of MIL-STD-105 which, along with MIL-STD-414 and MIL-STD-1235, use the AQL as the parameter of choice in selecting sampling plans. MIL-STD-105 and MIL-STD-414 both contain, as well as $c = 0$ plans, sampling plans that allow acceptance of a lot even though defects are found in the sample.

1 Choosing the Sampling Plan.

1-1 The usual method of choosing a sampling plan for any given lot size hinges on the arbitrary choice of the following factors:

- a. Producer's risk, alpha (α); probability of rejecting good quality lots.
- b. Consumer's risk, beta (β); probability of accepting poor quality lots.
- c. Acceptable quality level (AQL); p' considered to be good quality.
- d. Unacceptable quality level (LTPD or LQ); p' considered to be poor quality.
- e. Affordable sample size.

1-2 Let's look at these factors in more detail. Although arbitrary, factors a. through d. above can be used to identify two reference points on an OC curve, and an optimum sampling plan can then be chosen using the reference points.

1-2.1 The producer's risk (α) is defined as the probability of rejecting good quality lots, and the consumer's risk (β) is defined as the probability of accepting poor quality lots. The criterion that must be decided on is "how good or how bad" the quality is. This is why acceptable and unacceptable quality levels must be determined prior to using this method of sampling. It should again be emphasized that the choice of α , β , AQL, or LTPD is totally arbitrary. The classic definitions of AQL and LTPD or LQ, as contained in the "D" revision of MIL-STD-105, are :

a. Acceptable Quality Level (AQL). The AQL is that incoming quality (p') of product which is considered to be good. It is the maximum percent defective that, for the purpose of sampling inspection, can be considered satisfactory as a process average. The probability of rejecting a lot where the quality is equal to the AQL is called the producer's risk (α). It can also be said that the probability of accepting a lot (Pa) where the quality is equal to the AQL is $(1 - \alpha)$.

b. Lot Tolerance Percent Defective (LTPD) or Limiting Quality (LQ). The LTPD or LQ is that incoming quality (p') of product which is considered to be poor or unacceptable. The probability of accepting a lot (Pa) where the quality is equal to the LTPD or LQ is called the consumer's risk (β).

1-2.2 It should be pointed out here that the terms "good," "poor," "acceptable," and "unacceptable" are also arbitrary. To better understand the use of AQL and LTPD, consider the OC curves in Figure 2-3.1 of Chapter 2. In deriving these curves, the sample size and accept number for a lot size of 10 were arbitrarily chosen and the fraction defective and probability of acceptance were mathematically derived for various numbers of defective items. This produced the OC curves without regard to α , β , AQL, nor LTPD, thus showing that none of these factors are imperative in developing an OC curve. They are, in fact, nothing more than risk factors of accepting or rejecting lots with an assumed level of fraction defectives that have been subjectively agreed upon by both the producer and the consumer and may be set at any level of percent defective or probability of acceptance. Assuming that the producer and the consumer have agreed to an AQL of 0.01 (1.0%), a producer's risk of 0.05 (5.0%), an LQ of 0.06 (6.0%), and a consumer's risk of 0.10 (10.0%), the producer has agreed to accept the risk that a product lot

SAMPLING TO A SPECIFIED AQL (continued)

containing 1.0% defective items ("good" quality) will, over the long run, be rejected as a result of 5.0% of the inspections conducted. The consumer, likewise, has agreed that he is willing to accept the risk that a product lot containing 6.0% defective items ("poor" quality) will, over the long run, be accepted as a result of 10% of the inspections conducted. Note that all four of these factors are arbitrarily determined and could have been set at any value between zero and 1.0 (100%). The fact that, by sampling, the consumer is willing to accept the risk that an accepted lot may contain some defective items does not mean that he is willing to accept known defective items. All items known to be defective must be corrected or replaced.

1-2.3 To exemplify how these reference points can be portrayed pictorially, consider that the following requirements have been established:

$$\begin{aligned} a &= 0.05 \\ \beta &= 0.10 \\ AQL &= 0.01 (1.0 \%) \\ LQ &= 0.06 (6.0 \%), \end{aligned}$$

In other words, the probability of accepting a 1.0 percent defective lot will be $1 - a = 0.95$, and the probability of accepting a 6.0 percent defective lot will be $\beta = 0.10$. The values chosen in this example for a , β , AQL, and LQ are not mandatory. Of course, any sampling plan will ideally yield 100% probability of accepting a lot containing no defective items. Thus, three reference points on the OC curve have been established as follows:

- p' (Percent Defective) = 0.00; Pa (Probability of Acceptance) = 1.00 (100%).
- $p' = 0.01 (1.0\%)$; $Pa = 0.95 (95\%)$.
- $p' = 0.06 (6.0\%)$; $Pa = 0.10 (10\%)$.

1-2.4 The reference points are shown pictorially in Figure 30-1. The importance of these points is that the OC curve of the chosen sampling plan should pass through the reference points. The probability of acceptance for each percent defective can be determined using theory of probability and associated mathematics for given lot sizes, sample sizes, and acceptance numbers. From each pair (sample size and acceptance number) for a given lot size, a discreet OC curve may be constructed, and experimentation will produce a curve that satisfies or approximates the chosen a , β , AQL, and LQ. Such a curve for the example discussed is shown in Figure 30-2 where it is discovered that for a lot size of 1,000, a sample size of 85 and an acceptance number of two will closely approximate the chosen reference points and is the optimum plan for those reference points pertaining to that lot. Changing either the lot size, sample size, or acceptance number will move the curve further from one or both reference points. If the acceptance number remains at two and the sample size is increased, the OC curve will pass closer to the reference point (LQ, β) but further from the reference point (AQL, $1 - a$). If the sample size is decreased with the acceptance number remaining at two, the OC curve will pass closer to the reference point (AQL, $1 - a$), but further from the reference point (LQ, β). On the other hand, if the sample size remains unchanged (at 85) and the acceptance number is changed, the OC curve will pass further away from both reference points.

2 It is now apparent that the AQL is not needed to design nor select an effective sampling plan but is, along with its associated parameters (a , β , and LTPD), used due to the availability of the AQL based tables of MIL-STD-105 and MIL-STD-414. The $c = 0$ sampling plans and tables will be used once they are available.

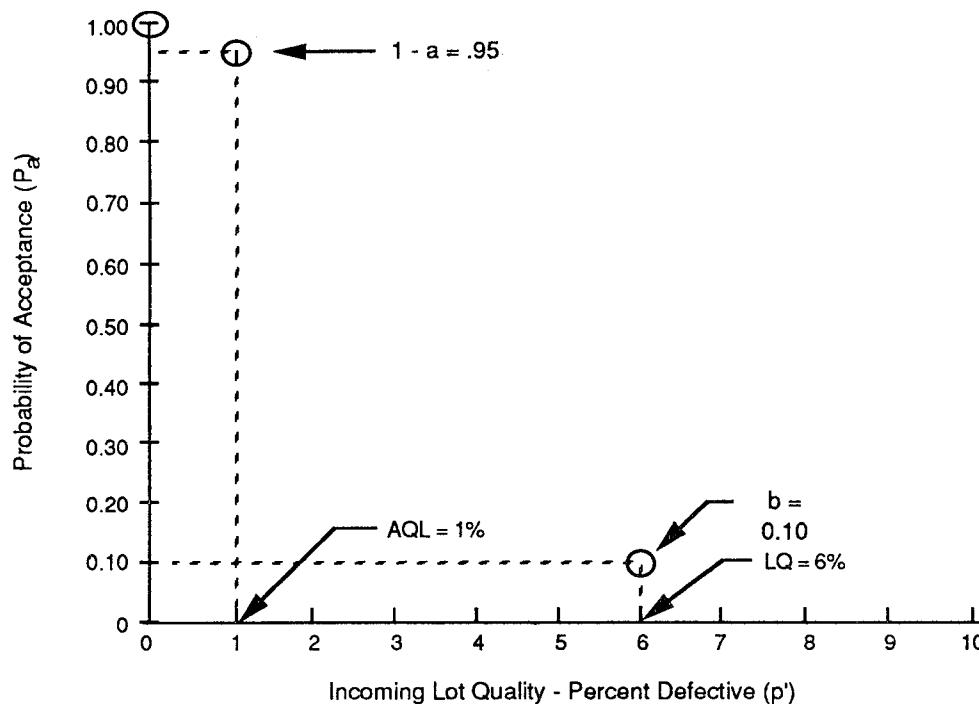
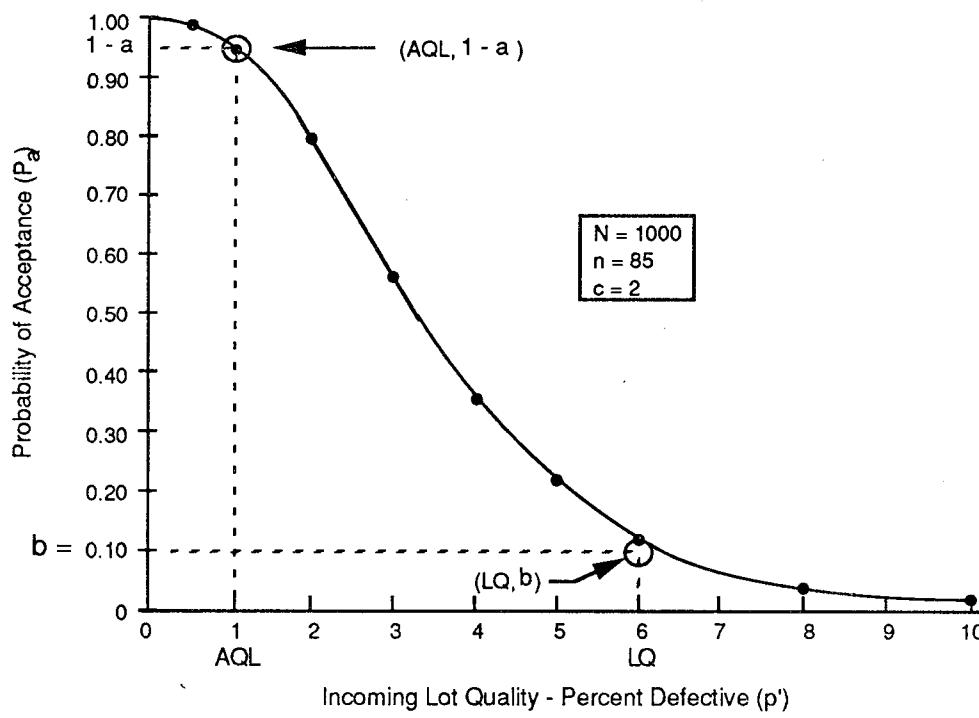


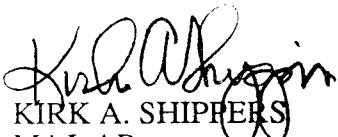
Figure C-1. Reference Points for OC Curves

Figure C-2. OC Curve for Sampling Plan, $N = 1000$, $n = 85$ and $c = 2$

The proponent agency of this publication is the U.S. Army Missile Command (Research, Development, and Engineering Center, Product Assurance Directorate; Quality Engineering Division). Users are invited to send comments to the Commander, MICOM, ATTN: AMSMI-RD-QA-QE, Redstone Arsenal, AL 35898.

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